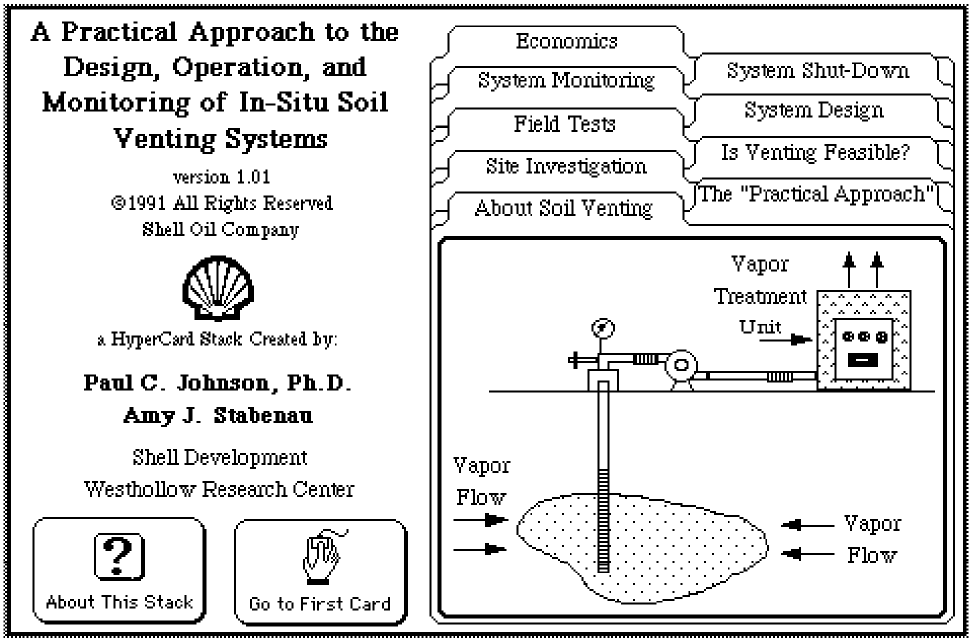
HyperVentilate
Users Manual

A Software Guidance System Created for Vapor Extraction Applications



by

Paul C. Johnson, Ph.D.

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Shell Development
Westhollow Research Center
Environmental R&D
P. O. Box 1380
Houston, TX 77251

Apple® Macintosh™ HyperCard™
compatible version 1.01

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Comments/Suggestions?

Comments and/or suggestions about the usefulness of this program can be mailed to:

Paul C. Johnson
Shell Development
Westhollow Research Center
P.O. Box 1380
Room EC-649
Houston, TX 77251-1380

Please do not call the author and/or Shell with questions about the use or interpretation of results from this program.

Foreword

HyperVentilate is a software guidance system for vapor extraction (soil venting) applications. Initial development of this program occured under the Apple Macintosh HyperCard environment, due to its programming simplicity, ability to incorporate text and graphics, and interfacing with other Macintosh programs (such as FORTRAN codes, etc.). The objective was to create a user-friendly software package that could be both educational for the novice environmental professional, and functional for more experienced users.

HyperVentilate *will not* completely design your vapor extraction system, tell you exactly how many days it should be operated, or predict the future. It *will* guide you through a structured thought process to: (a) identify and characterize required site-specific data, (b) decide if soil venting is appropriate at your site, (c) evaluate air permeability test results, (d) calculate the minimum number of vapor extraction wells, and (e) quantify how results at your site might differ from the ideal case.

HyperVentilate is based on the article "*A Practical Approach to the Design, Operation, and Monitoring of Soil Venting Systems*" by P. C. Johnson, C. C. Stanley, M. W. Kemblowski, J. D. Colthart, and D. L. Byers [Ground Water Monitoring Review, Spring 1990, p.159 - 178]. The software performs all necessary calculations and contains "help cards" that define the equations used, perform unit conversions, and provide supplementary information on related topics. In addition, a 62-compound user-updatable library (to a maximum of 400 compounds) is also included.

HyperVentilate version 1.01 for the Apple Macintosh requires an Apple Macintosh (Plus, SE, SE/30, II, IIX, or portable) computer equipped with at least 1 MB RAM (2 MB preferred) and the Apple HyperCard Software Program (v.2.0 or greater)

This manual is not intended to be a primer on soil venting (although the software is) and it is assumed that the user is familiar with the use of an Apple Macintosh personal computer.

Table of Contents

I. *Introduction*

In situ vapor extraction, or soil venting is recognized as an attractive remediation alternative for "permeable" soils contaminated with "volatile" compounds. As Figure 1 illustrates, vapors are removed from extraction wells, thereby creating a vacuum and vapor flow through the subsurface. Until the residual contamination is depleted, contaminants will volatilize and be swept by the vapor flow to extraction wells. While its use has been demonstrated at service stations, Superfund sites, and manufacturing locations (see Hutzler et al. [1988] for case study reviews), vapor extraction systems are currently designed more by intuition than logic. In fact, many systems are installed at sites where the technology is not appropriate.

"A Practical Approach to the Design, Operation, and Monitoring of In Situ Soil Venting Systems" [Johnson et al. 1990a - see Appendix G] is a first attempt at creating a logical thought process for soil venting applications. The article, which is based on earlier results of Thornton and Wootan [1982], Marley and Hoag [1984], Johnson et al. [1990], and discussions with several of these authors, describes a series of calculations for determining: (a) if soil venting is appropriate at a given site, (b) limitations of soil venting, and (c) system design parameters, such as minimum number of extraction wells and potential operating conditions.

HyperVentilate is a software guidance system based on the Johnson et al. [1990a] article. The software performs all necessary calculations and contains "help cards" that define the equations used, perform unit conversions, and provide supplementary information on related topics. In addition, a 62-compound updatable chemical library (to a maximum of 400 compounds) is included.

Initial development of this program occured under the Apple Macintosh HyperCard environment, due to its programming simplicity, ability to incorporate text and graphics, and interfacing with other Macintosh programs (such as FORTRAN codes, etc.). The objective was to create a user-friendly software package that could be both educational for the novice environmental professional, and a functional tool for more experienced users. The OASIS [1990] system created at Rice University for groundwater contamination problems is another excellent example of the use of HyperCard as a technology transfer tool.

This document is a users manual for **HyperVentilate**. It contains sections describing the installation and operation of the software. During the development of **HyperVentilate**, the goal was to create a guidance system that could be used with little or no instruction. Experienced Apple Macintosh users, therefore, can load and explore the capabilities of this program after glancing at the "*Loading HyperVentilate Software*" section. Those users that are less comfortable about exploring software without a manual are encouraged to read through it once, and work through the sample problem. It is intentionally brief, and a beginner should be able to navigate through the system in less than a couple hours. It is assumed that the user has some previous Macintosh experience. If not, consult a Macintosh users manual for a quick tutorial.

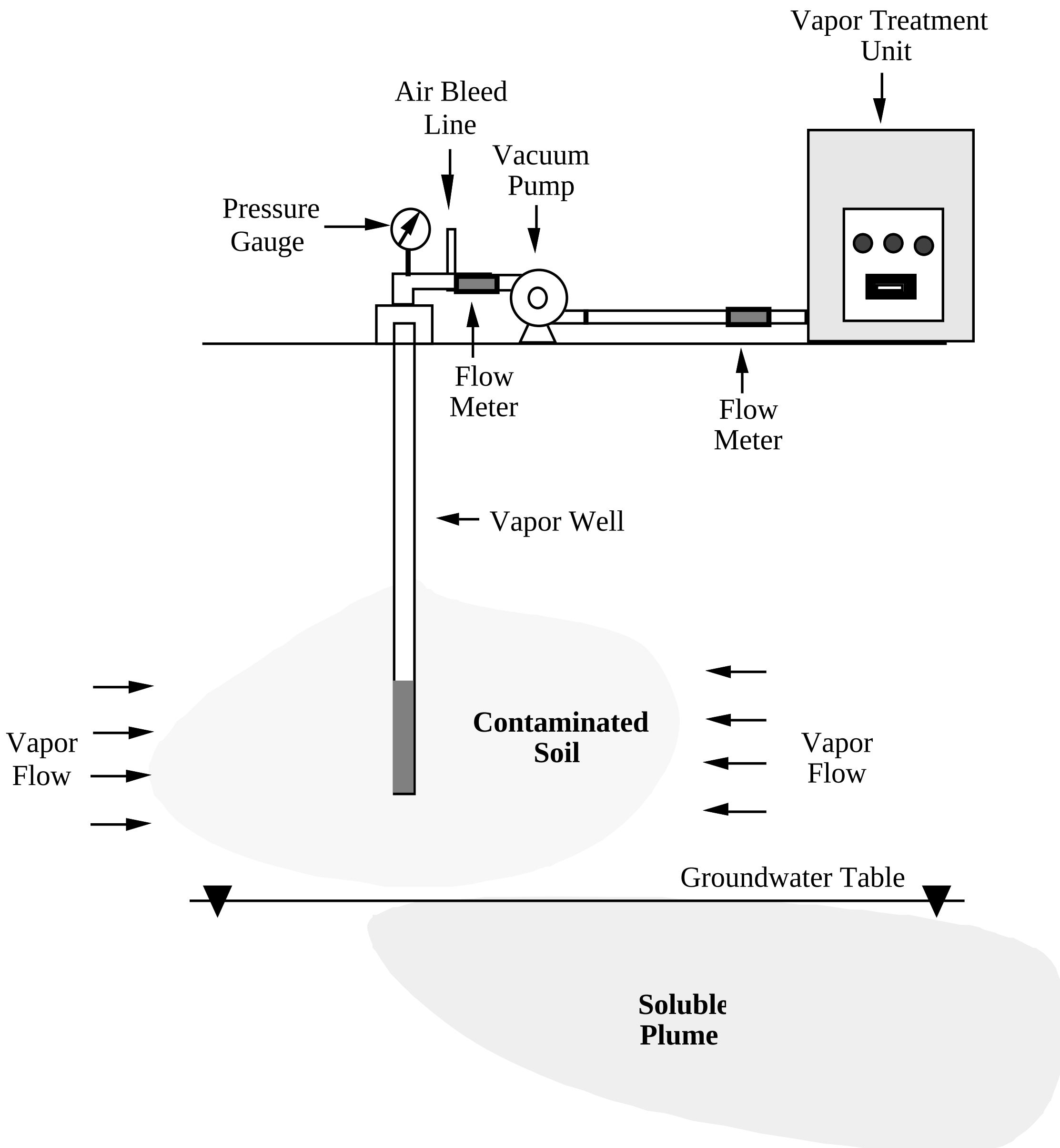

Figure 1. Schematic of a typical vapor extraction operation.

II. *Definition of Some Terms Appearing in this Manual*

button - an object on a "card" that causes some action to be performed when "clicked" on
card - an individual screen that you view on your monitor
click - refers to the pressing and releasing of the button on your mouse
drag - refers to holding down the mouse button while moving the mouse
field - a text entry location on a "card"
HyperCard - a programming environment created by Apple Computer, Inc.
mouse - the device used to move the cursor within your monitor
select - refers to "dragging" the cursor across a "field"
stack - a group, or file, of "cards"

III. *Software/Hardware Requirements*

Apple Macintosh **HyperVentilate** version 1.01 requires an Apple Macintosh (or equivalent) computer equipped with at least 1 MB RAM (2 MB preferable), a hard disk, and the Apple HyperCard Software Program (v 2.0). Check to make sure that your system software is compatible with your version of HyperCard.

IV. *Loading HyperVentilate Software*

HyperVentilate is supplied on an 800 kB double-sided, double density 3.5" diskette. Follow the instructions listed below to insure proper operation of the software.

1) Insert the **HyperVentilate** disk into your computer's floppy drive. The **HyperVentilate** disk should contain the files:

    - "Soil Venting Stack"
    - "Soil Venting Help Stack"
    - "System Design"
    - "Air Permeability Test"
    - "Aquifer Characterization"
    - "Compound List Update"
    - "HypeVent"
    - "f77.rl"

2) Copy these files onto your hard disk. **They must be copied into the folder that contains the "HyperCard" program, or else the software will not operate properly.**

3) Eject the **HyperVentilate** disk

V. *Using HyperVentilate*

The authors of **HyperVentilate** intend it to be an application that requires little pre-training for the user. It is mouse-driven and instructions are included on each card, so please take the time to read them when you first use **HyperVentilate**.

This section of the users manual is divided into three subsections. Start-up instructions are given in the first, basic features of the cards are described in the second, and a sample exercise is presented in the third. For reference, copies of all cards, as well as more details on each are given in Appendices A through F.

V.1. Starting HyperVentilate

1) Those users with color monitors should use the "Control Panel" (pull down the " " menu and select "Control Panel", then click on the "Monitors" icon) to set their monitors to black and white, and two shades of grey.

2) To avoid unnecessary "card-flipping", set the "Text Arrows" option in your "Home" stack "User Preferences" card to <u>on</u>. You can get to this card from within any HyperCard application by selecting "Home" under the "Go" menu. This will take you to the first card in the "Home" stack. At this point click on the left-pointing arrow and the "User Preferences" card will appear on your screen. Then click on the square to the left of "Text Arrows" until an "X" appears in the square.

3) **HyperVentilate** is started by double-clicking on the "Soil Venting Stack" file icon from the Finder (or Desktop), or by choosing "Open" under the "File" menu (*Note that using a more advanced version of HyperCard than the one under which this system was developed (v 2.0) may require you to first "convert" each of the seven HyperCard stacks contained in* ***HyperVentilate***).

4) Your monitor should display the card shown in Figure 2. Note that there are a number of buttons on this card; there are two at the lower left corner, and then each file folder tab is also a button (some cards may contain less obvious "hidden" buttons; try clicking on the authors name on the title card for example). Clicking on any of these will take you to another card. For example, clicking on the "About This Stack" button will take you to the card shown in Figure 3, which gives a brief description about the use of buttons and fields. Read this card well.

5) Explore for a few minutes. Try to see where various buttons will take you, try entering numbers in fields, or play with calculations. Again, just remember to read instructions given on the cards.

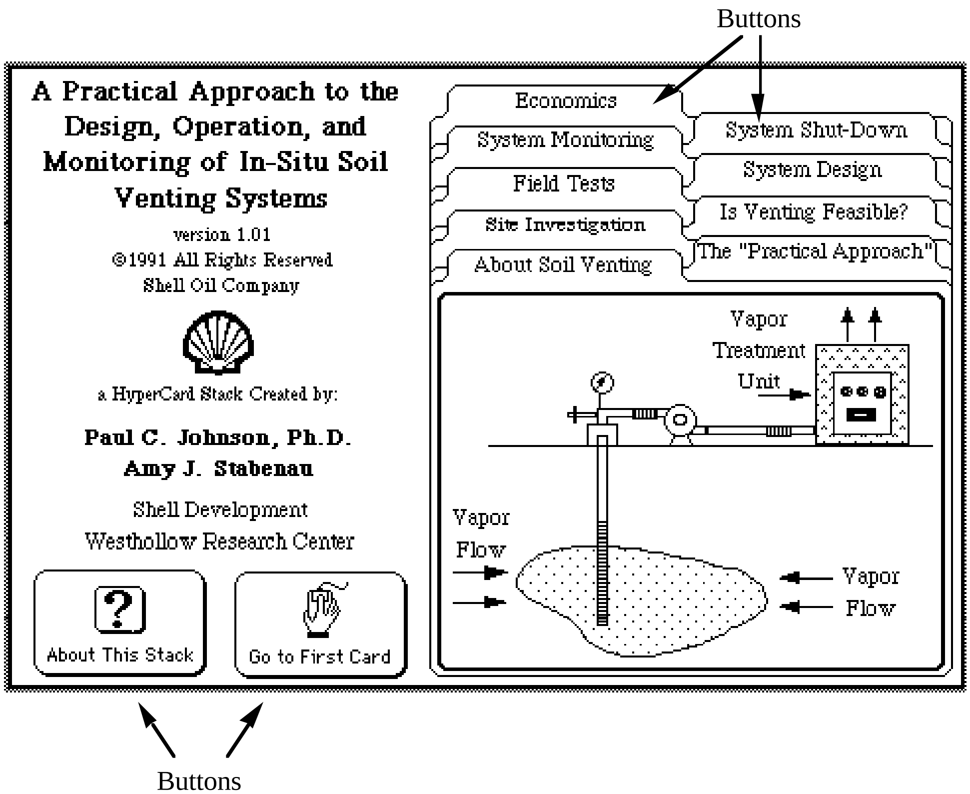

Figure 2. First Card of the "Soil Venting Stack" stack.

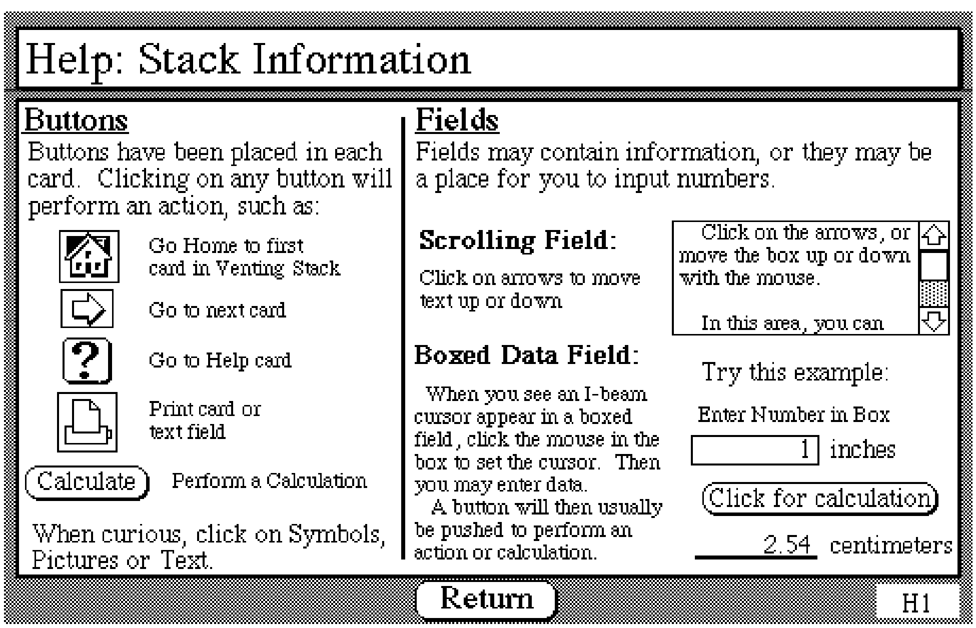

Figure 3. Card H1 of the "Soil Venting Help Stack" stack.

V.2. General Features of Cards

Figures 4 and 5 are examples of cards from the "Soil Venting Stack" stack and "System Design" stack. There are a few general features of these cards that users should understand:

a) Each card (with the exception of the first card of the "Soil Venting Stack" stack) has been numbered for easy reference with the printouts given in Appendices A through F. In the "Soil Venting Stack" these numbers appear in the bottom center of each card (i.e. number "3" in Figure 4). In other stacks these numbers appear at either the top or bottom corners of the card (i.e. "SD1" in Figure 5).

b) Arrow buttons are included at the bottom of some cards. Clicking on right-pointing arrow will advance you to the next card in the stack; clicking on the left-pointing arrow will take you in the opposite direction.

c) The identifying card numbers in the "Soil Venting Stack" stack are also fields into which text can be typed. You can skip to other parts of the "Soil Venting Stack" stack by selecting this field, typing in the card number of your destination (within the "Soil Venting Stack"), and then hitting the "return" key.

d) Many cards have a house button in the lower left corner. Clicking on this button will take you to the first card of the "Soil Venting Stack" stack, which is the card displayed at start-up (see Figure 2).

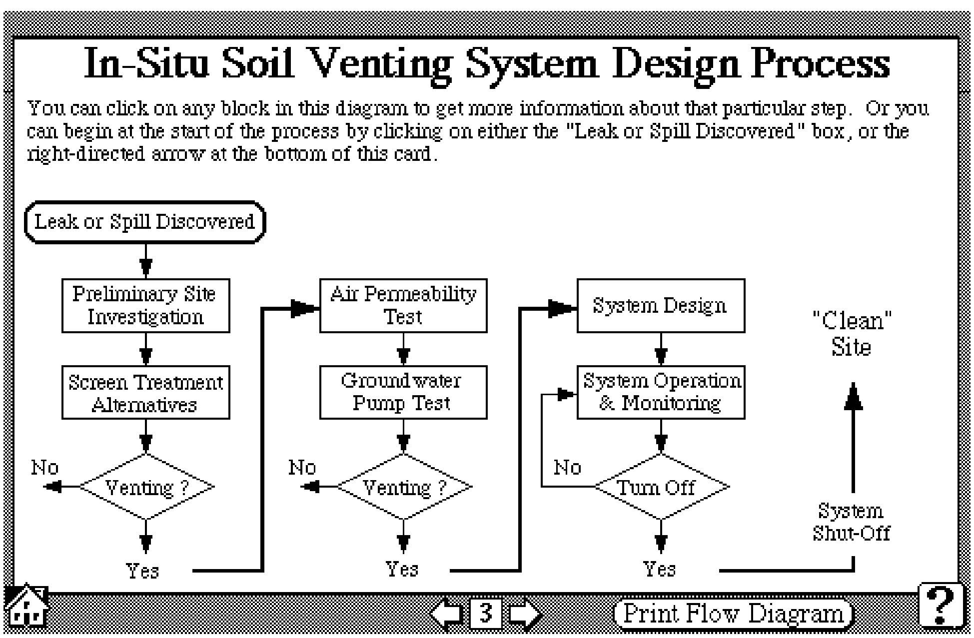

Figure 4. Card 3 of the "Soil Venting Stack" stack.

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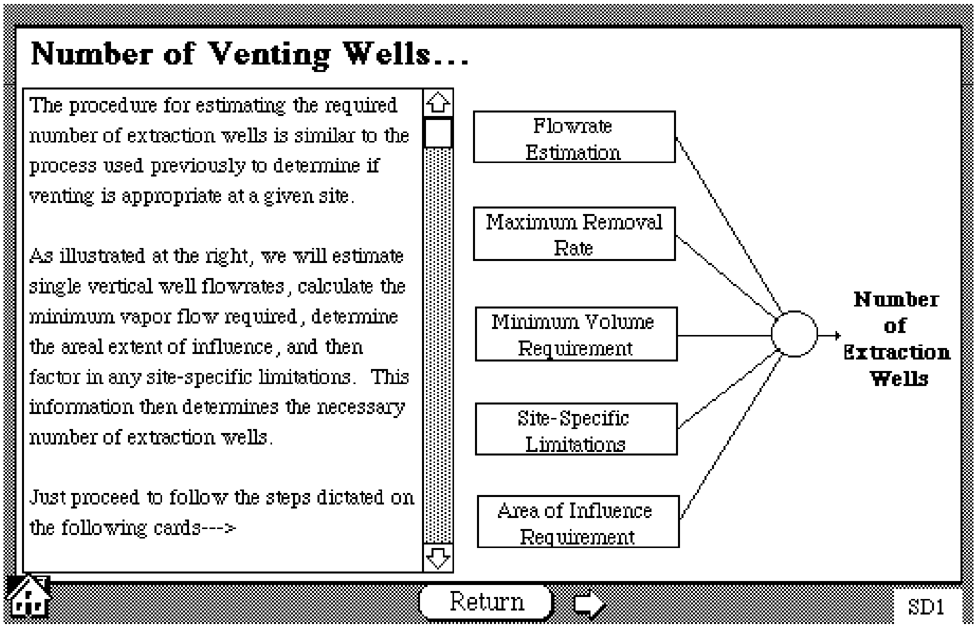

Figure 5. Card SD1 of the "System Design" stack.

V.3. Sample Problem Exercise

In the following a sample problem is executed in excruciating detail. Those not wishing to work along with the example are encouraged to utilize Appendices A through F as references for more details on the less obvious functions of some cards.

This "Sample Problem Exercise" is divided into to four subsections that address: navigating through **HyperVentilate** (§V.3.1), screening sites to see if soil venting is an appropriate technology (§V.3.2), interpreting air permeability test data (§V.3.3), and guidance for designing soil venting systems (§V.3.4).

V.3.1 Navigating Through HyperVentilate

Step 1: Location: The "Desktop" or Finder.
Action: Start-up **HyperVentilate** by double-clicking on the "Soil Venting Stack" icon, or click once on this icon and then choose "Open" from the "File" menu.
Result: **HyperVentilate** will start-up and display the title card (Figure 2).

Step 2: Location: Title Card of the "Soil Venting Stack" stack.
Action: Click on the "About This Stack" button.
Result: You are now at card H1 of the "Soil Venting Help Stack" stack (Figure 3).

Step 3: Location: Card H1 of the "Soil Venting Help Stack" stack.
Action: Play with the buttons and scrolling field. Practice entering a number in the field in front of "inches". Place the cursor in the box. It will change from a hand to an "I-bar" as it enters the field. Hold down the mouse button and drag the I-bar across the entry, which will become hilited. Now type in another number, or hit the delete key. Practice until you feel comfortable selecting text and entering numbers. Then click on the "Click for Calculation" button. When you are done practicing, click on the "Return" button.
Result: Return to the title card of the "Soil Venting Stack" (Figure 2).

Step 4: Location: Title Card of the "Soil Venting Stack" stack.
Action: Click on the "Economics" file folder tab.
Result: You are now at card 27 of the "Soil Venting Stack" stack. Take a quick glance at this card, which is displayed in Figure 6.

Step 5: Location: Card 27 of the "Soil Venting Stack" stack.
Action: Click on the "House" button in the lower left corner.
Result: You are back at the title card (Figure 2).

Step 6: Location: Title card of the "Soil Venting Stack" stack.
Action: Click on the "Go to First Card" button.
Result: You are now at card 1 of the "Soil Venting Stack" stack (Figure 7).

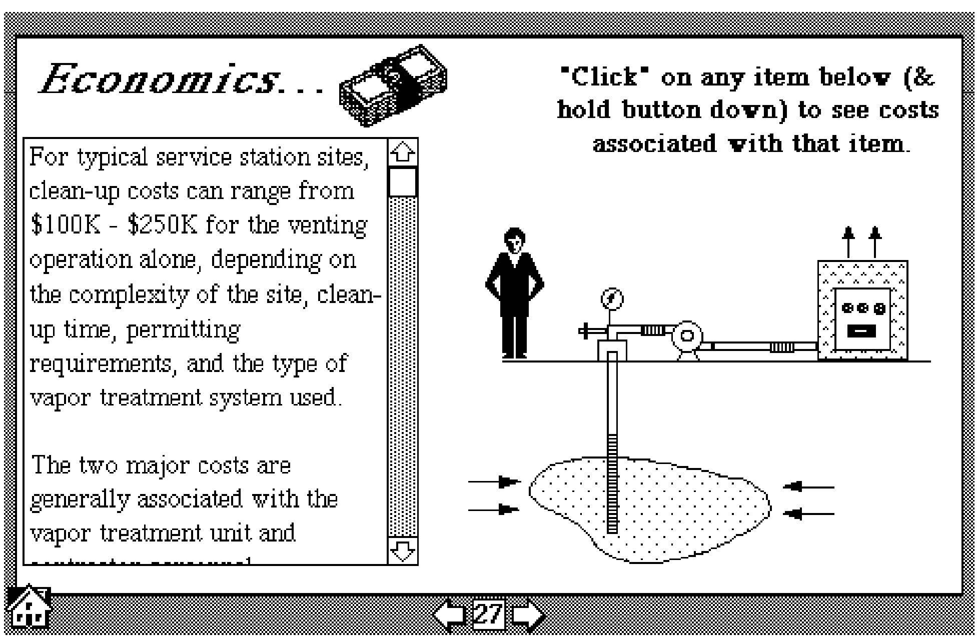

Figure 6. Card 27 of the "Soil Venting Stack" stack.

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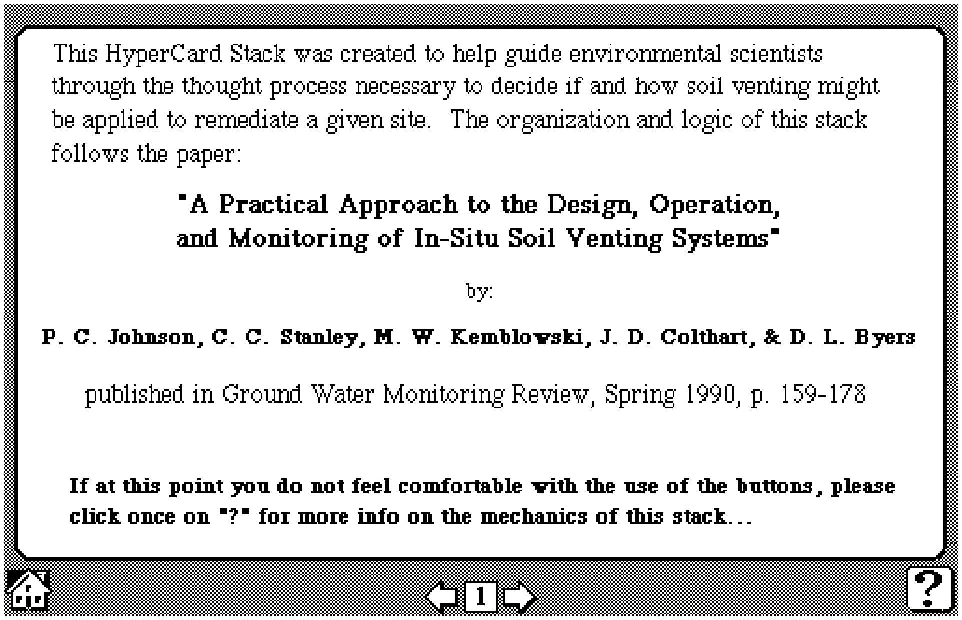

Figure 7. Card 1 of the "Soil Venting Stack" stack.

Step 7: Location: Card 1 of the "Soil Venting Stack" stack.
Action: Click on the right-pointing arrow.
Result: You are now at Card 2 of the "Soil Venting Stack" stack (Figure 8).

Step 8: Location: Card 2 of the "Soil Venting Stack" stack.
Action: Read the text, and click on the "down" and "up" arrows on the displayed text field under "***About Soil Venting...***" to make the field scroll. Then click on the left-pointing arrow at the card bottom.
Result: You are now back at card 1 of the "Soil Venting Stack" (Figure 7).

Step 9: Location: Card 1 of the "Soil Venting Stack" stack.
Action: Click on the right pointing arrow.
Result: You are again at card 2 of the "Soil Venting Stack" stack (Figure 8). By now you should feel comfortable using the left- and right-pointing arrows to travel through the stack.

Step 10: Location: Card 2 of the "Soil Venting Stack" stack.
Action: Click on the "?" button in the lower right corner of the card. This button indicates that there is a "Help" card containing additional information.
Result: You are now at card H2 of the "Soil Venting Help Stack" stack (Figure 9). Scroll through the list of references, then click on the "Return" button to return to card 2 of the "Soil Venting Stack" stack.

At this point you should feel comfortable navigating around in **HyperVentilate**.

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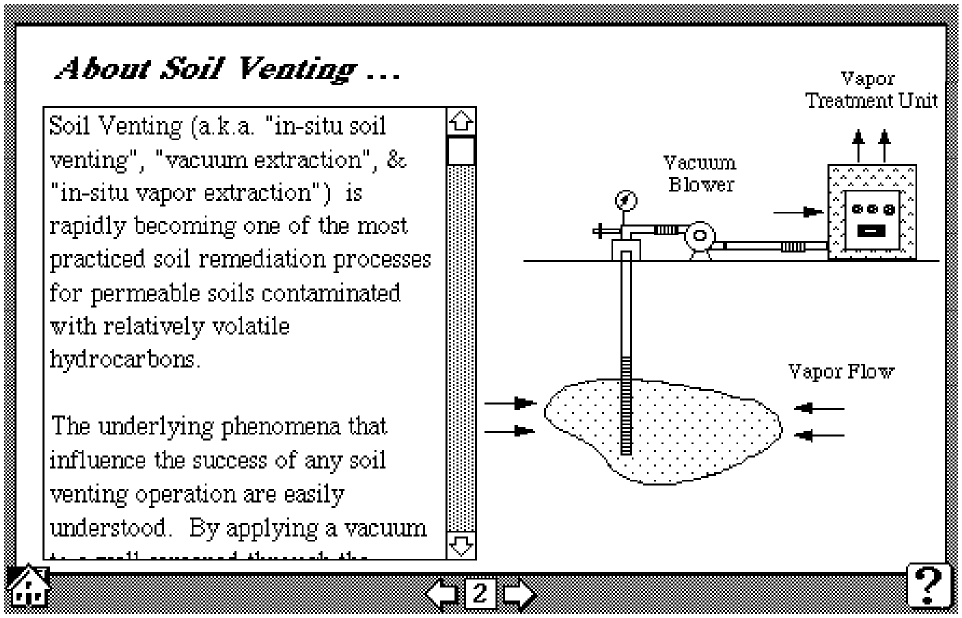

Figure 8. Card 2 of the "Soil Venting Stack" stack.

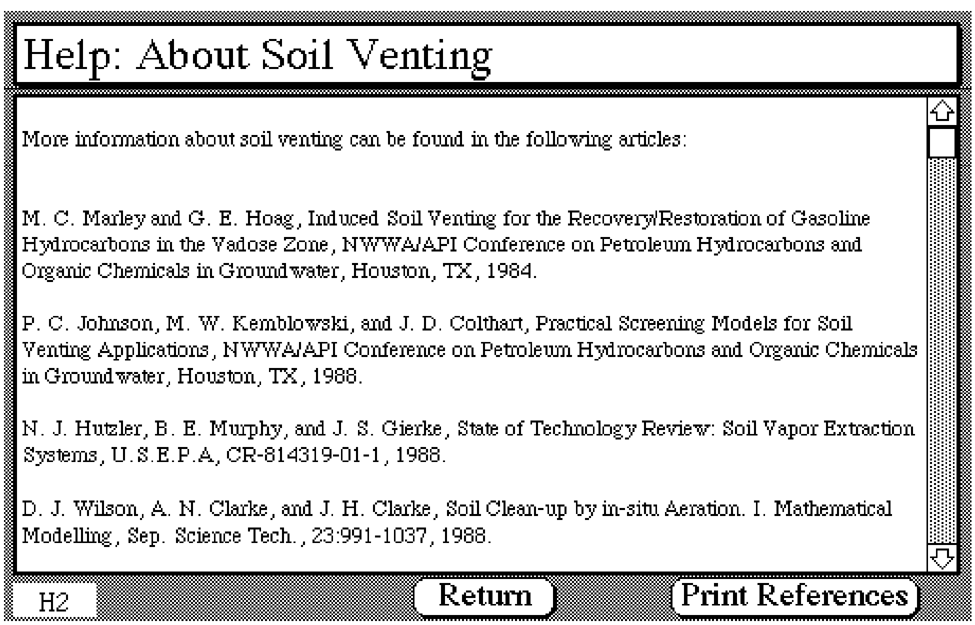

Figure 9. Card H2 of the "Soil Venting Help Stack" stack.

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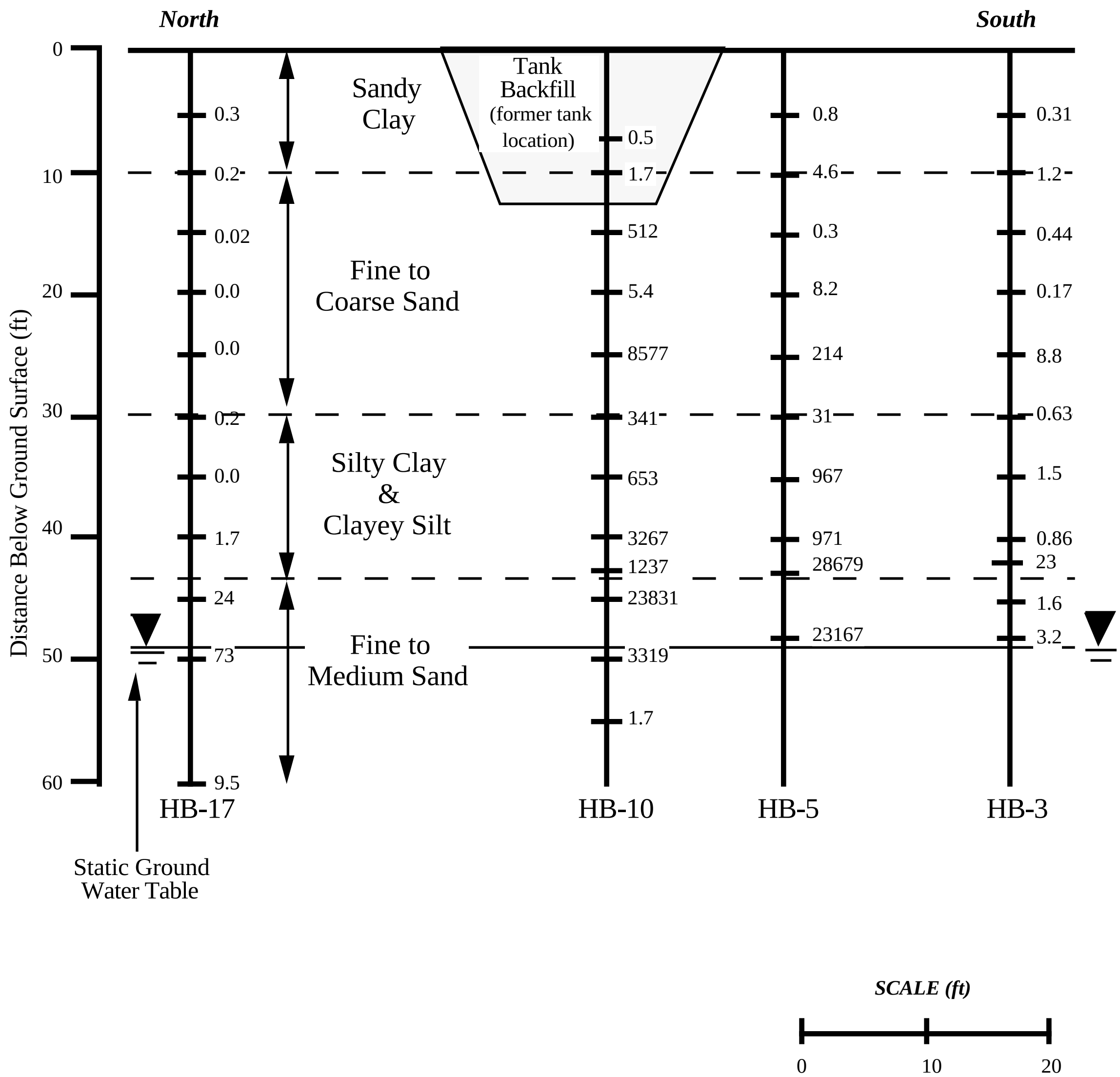
V.3.2 Sample Problem Exercise - Is Venting Appropriate?

In §V.3.2. you will work through an example problem to illustrate how one might decide if venting is appropriate at any given site. For the purpose of this example we will use the example site information given in Figure 10.



Contamination Type: Weathered Gasoline

Figure 10. Sample site data (Johnson et al. [1990a]). Total petroleum hydrocarbons (TPH) [mg/kg] values are noted for each boring.

Using your newly developed navigational skills and the right pointing arrow located at the bottom of each card, slowly step your way through the stack until you reach card 7 of the "Soil Venting Stack" stack (Figure 11). Take your time to read the text and "Help" cards associated with each card along the way.

Step 1: Location: Card 7 of the "Soil Venting Stack" stack.
Action: Read this card. It explains the process that you will use to decide if venting is appropriate. Then advance to card 8 of the "Soil Venting Stack" stack.
Result: You are now at card 8 of the "Soil Venting Help Stack" stack (Figure 12).

Step 2: Location: Card 8 of the "Soil Venting Help Stack" stack.
Action: Read the instructions on this card. Take the time to read the information on the two "Help" cards: "Info about Calculation" and "About Soils (& Unit Conversions)".

Now we will evaluate the efficacy of applying in situ soil venting to the lower soil zone (45 - 50 ft below ground surface) in Figure 10, which is composed of fine to medium sands. It also is the zone of highest hydrocarbon residual levels (>20000 mg/kg TPH in some areas).

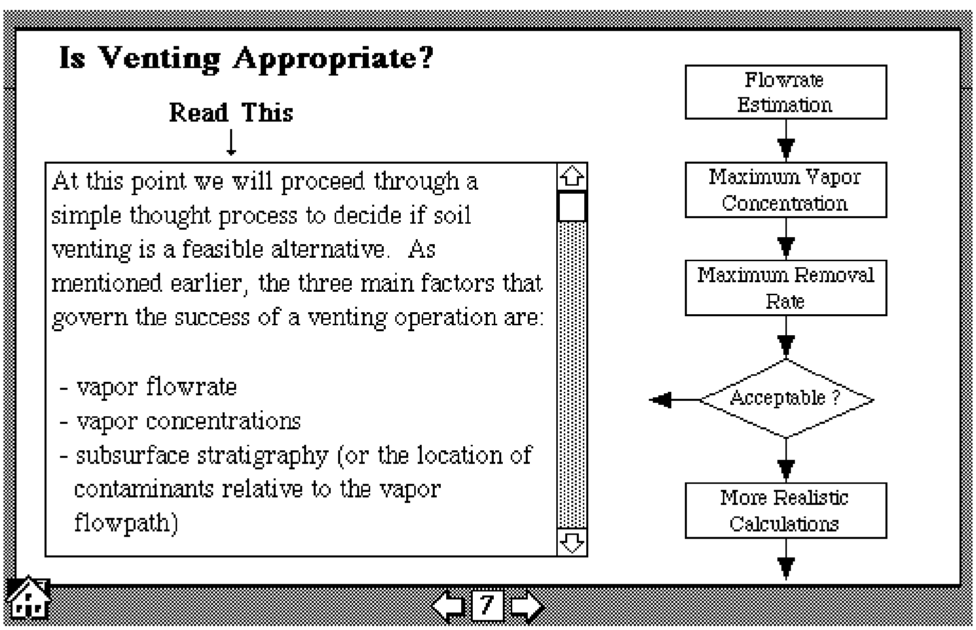


Figure 11. Card 7 of the "Soil Venting Stack" stack.

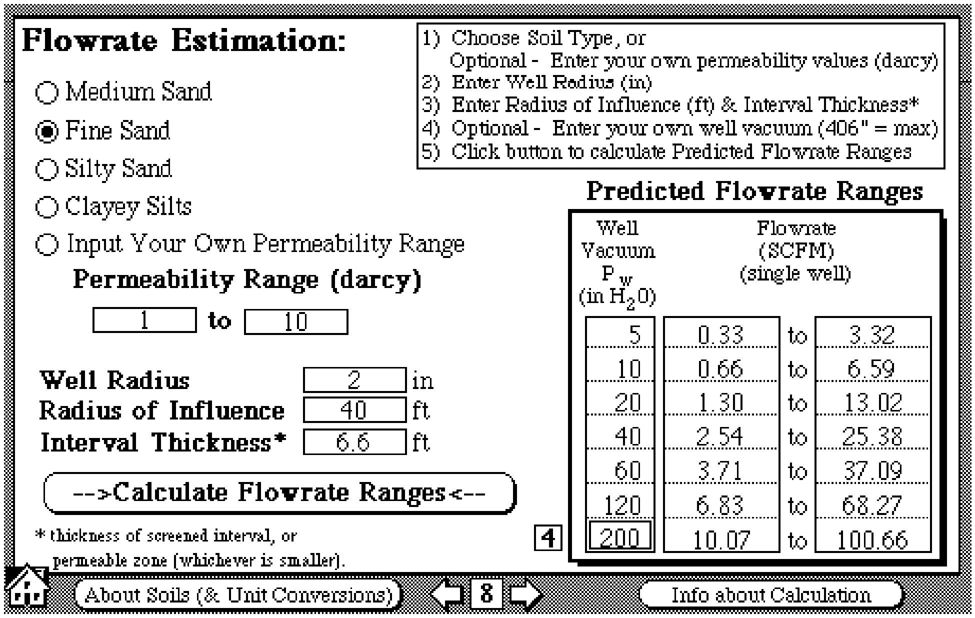


Figure 12. Card 8 of the "Soil Venting Stack" stack.

Step 3: Location: Card 8 of the "Soil Venting Stack" stack.
Action: Choose the "Fine Sand" soil type, and enter:

well radius =	2 in
radius of influence =	40 ft
interval thickness =	6.6 ft
user input vacuum =	200 in H_2O

into the appropriate fields, then click on the "-->Calculate Flowrate Ranges<--" button.

Result: The flowrate ranges are calculated and displayed. Your screen should now look like Figure 12. The calculated values are estimates of the flowrate to a single vertical well (and are only valid estimates when your conditions are consistent with the assumptions built into the calculation - see Johnson et al. [1990a, b] for more details).

Step 4: Location: Card 8 of the "Soil Venting Stack" stack.
Action: Click on the right pointing arrow to advance to card 9. Read the information on this card, then advance to card 10
Result: You are now at card 10 of the "Soil Venting Stack" stack (see Figure 13).

Step 5: Location: Card 10 of the "Soil Venting Stack" stack.
Action: Assume that the soil temperature at our sample site is 18^{o} C. Enter this value in the appropriate field, then hit the "return" key. This action clears all values from the other fields.

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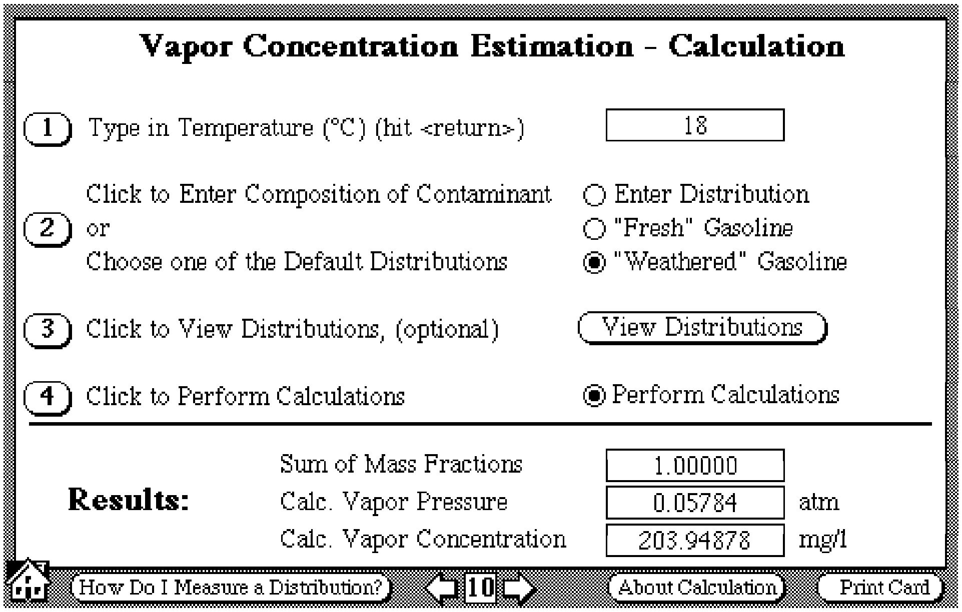

Figure 13. Card 10 of the "Soil Venting Stack" stack.

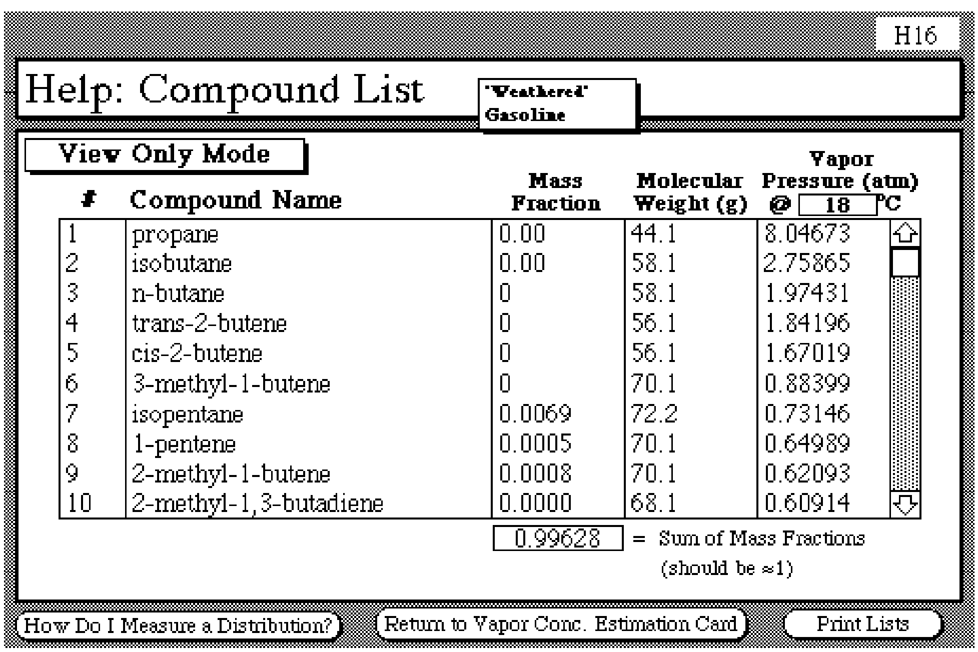

Figure 14. Card H16 of the "Soil Venting Help Stack" stack.

At this site the residual hydrocarbon is a "weathered" gasoline, so choose this selection from the three composition options listed. The "Fresh" and "Weathered" gasoline selections correspond to pre-programmed compositions that are useful for estimation purposes. If you knew the composition of your residual, then you could enter it by selecting the "Enter Distribution" option. Click on the "View Distributions" button to take a look at the compound library and the pre-specified composition of "weathered" gasoline.

Result: You are now at card H16 of the "Soil Venting Help Stack" stack (see Figure 14).

Step 6: Location: Card H16 of the "Soil Venting Help Stack" stack.

Action: View the library and pre-specified composition. If you are interested, explore some of the help cards. Then click on the "Return to Vapor Conc. Estimation Card" button to return to card 10 of the "Soil Venting Stack" stack.

Result: You are now at card 10 of the "Soil Venting Stack" stack (Figure 13).

Step 7: Location: Card 10 of the "Soil Venting Stack" stack.

Action: Click on the "Perform Calculations" button.

Result: **HyperVentilate** calculates the maximum possible vapor concentration corresponding to the specified composition and temperature. The results are displayed in Card 10 of the "Soil Venting Stack" stack, which should now look like Figure 13.

Step 8: Location: Card 10 of the "Soil Venting Stack" stack.

Action: Using the right-pointing arrow button, advance to card 11 of the "Soil Venting Stack" stack. Take the time to read the text, then click on the "Calculate Estimates" button

Result: You are at card 12 of the "Soil Venting Stack" stack. The calculated flowrates and maximum possible removal rates are displayed along with an updated list of the input parameters that you have entered. Your screen should look like Figure 15, if you have chosen the "lb/d" units.

Step 9: Location: Card 12 of the "Soil Venting Stack" stack.

Action: Click on the right-pointing arrow button. You are now at card 13 of the "Soil Venting Stack" stack. Read the text, then enter:

estimated spill mass = 4000 kg
desired remediation time = 180 d

Now click on the "-->Press to Get Rates<--" button

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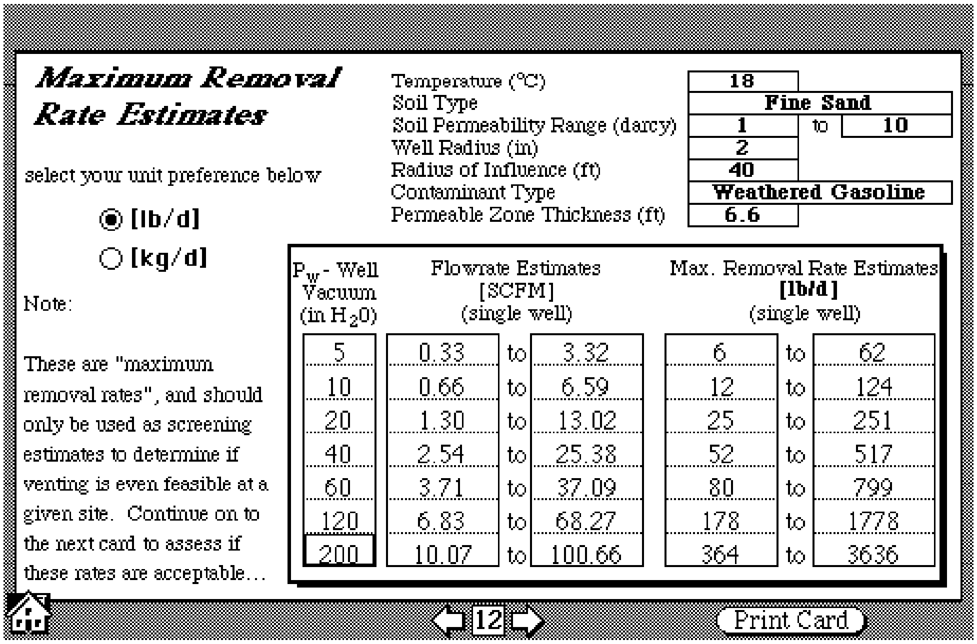

Figure 15. Card 12 of the "Soil Venting Stack" stack.

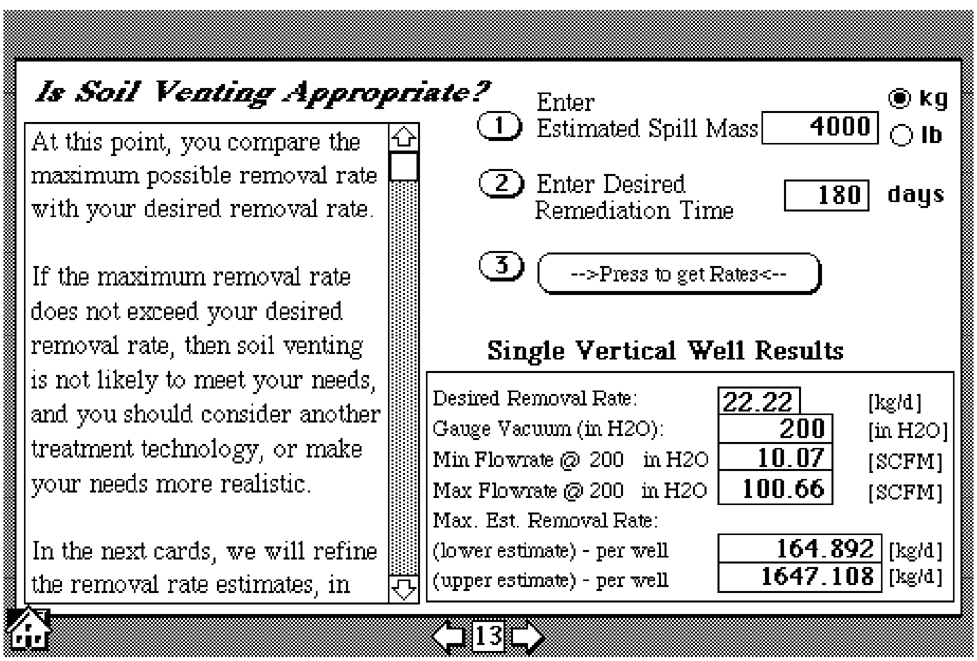

Figure 16. Card 13 of the "Soil Venting Stack" stack.

Result: Your screen should now look like Figure 16. Note that your desired removal rate (=22 kg/d) is less than the estimated maximum removal rates for a single vertical well (=165 to 1650 kg/d). At this point in the screening exercise, therefore, soil venting still appears to be a viable option.

Step 10: Location: Card 13 of the "Soil Venting Stack" stack.

Action: Click on the right-pointing arrow button to advance to card 14 of the "Soil Venting Stack" stack. Read the text, then advance to card 15 of the "Soil Venting Stack" by clicking on the right-pointing arrow button. Again, take the time to read the text, then advance to card 16 of the "Soil Venting Stack" stack. The focus of these cards is the prediction of vapor concentrations and removal rates as they change with time due to composition changes. It is important to try to understand the concepts introduced in these cards.

Result: You are at card 16 of the "Soil Venting Stack" stack (see Figure 17).

Step 11: Location: Card 16 of the "Soil Venting Stack" stack.

Action: This card is used to finalize your input data prior to calculating vapor concentration and residual soil contamination composition changes with time. Read the instructions in the order that they are numbered. Note that the summary table in the upper right corner of the card contains all the parameter values that you have input thus far. The instructions describe how to change these values, but at this point we will retain the displayed values. Because it is difficult to present the behavior of each compound in a mixture composed of an arbitrary number of compounds, the output is simplified by reporting the behavior in terms of "boiling point" ranges. This simply represents a summation of all compounds whose boiling points fall between pre-specified values. Presented in this fashion, the model results can be interpreted much more quickly. Click on the "tell me more about BP ranges..." button, read the help card, then return to card 16 of the "Soil Venting Stack" stack. Click on the "-->Set Default BP Ranges<--" button. Your screen should now look like Figure 17. Click on the "Generate Predictions" button

Result: The message "Sit Back and Relax..." will appear on your screen, followed by a screen on which the following appears:

"Copyright © Absoft Corp 1988
Copyright © Shell Oil Co 1990
HANG ON ----- YOU WILL BE RETURNED TO HYPERCARD...
OF COMPOUNDS IN LIBRARY = 62"

Then card 17 of the "Soil Venting Stack" stack will appear.

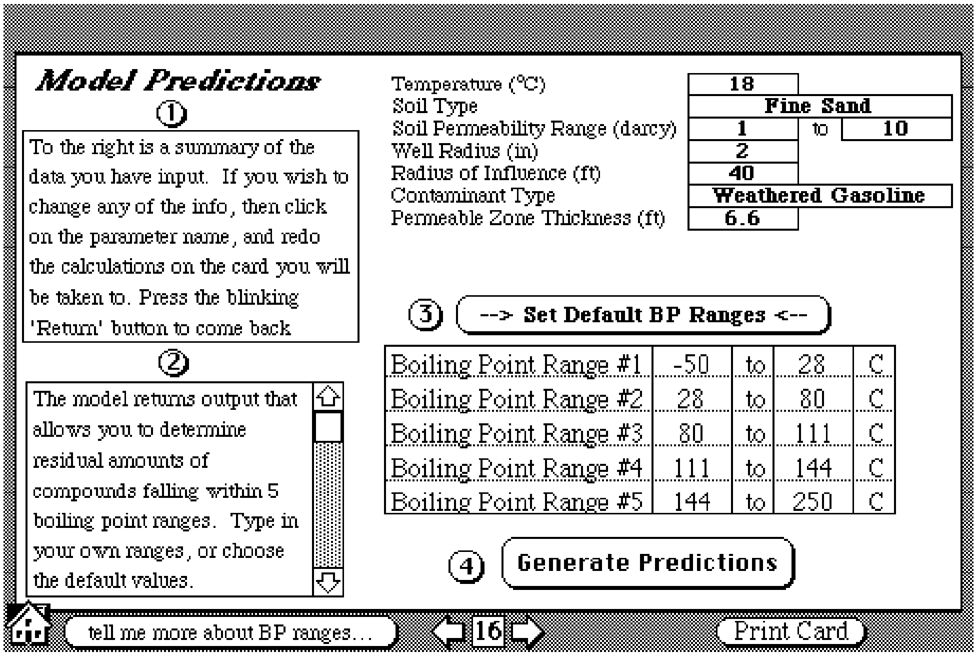

Figure 17. Card 16 of the "Soil Venting Stack" stack.

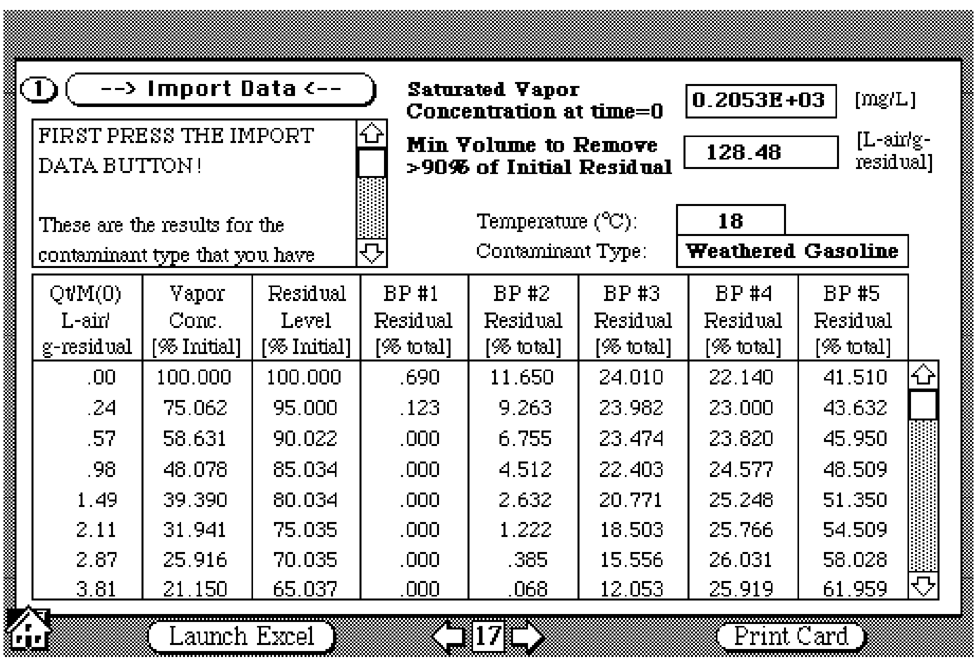

Figure 18. Card 17 of the "Soil Venting Stack" stack.

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Step 12: Location: Card 17 of the "Soil Venting Stack" stack.

Action: Read the instructions, then click on the "-->Import Data<--" button.

Result: Your screen should look like Figure 18. The table in the lower part of the card lists model predictions: vapor concentration and residual soil concentration (expressed as a percentage of their initial values), as well as the composition of the residual (expressed as a percentage of the total for each boiling point range) as a function of the amount of air drawn through the contaminated soil. Note that as the volume of air drawn through the soil increases, the vapor concentration and residual soil levels decrease, and the composition of the residual becomes richer in the less volatile compounds (BP Range #5). In the upper right corner of the card are displayed the saturated, or initial, vapor concentration and the minimum amount of air that must be drawn through the soil per gram of initial contaminant to achieve at least a 90% reduction in the initial residual level. This value is used in future calculations as a design parameter.

Step 13: Location: Card 17 of the "Soil Venting Stack" stack.

Action: Click on the right-pointing arrow to advance to card 18 of the "Soil Venting Stack" stack.

Result: You are at card 18 of the "Soil Venting Stack" stack, which should resemble Figure 19. Read the text. A summary of your input parameters appears on the right side of this card. At the bottom appears two calculated values representing the range of the minimum number of wells required to achieve a 90% reduction in the initial residual level in the desired remediation time. These values correspond to idealized conditions, however, they can be used to gauge the efficacy of soil venting at your site. For example, in this case the minimum number of wells ranges between 0.7 - 7, which is not an unreasonable number for a site the size of a service station. If the range had been 100 - 1000, then it might be wise to consider other remediation options.

It is important to recognize that model predictions are intended to serve as guidelines, and are limited in their ability to describe behavior that might be observed at any given site. One should use all the information available, in addition to idealized model predictions to make rational decisions about the applicability of soil venting.

Step 14: Location: Card 18 of the "Soil Venting Stack" stack.
Action: Click on the right-pointing arrow button to advance to card 19.
Result: You are now at card 19 of the "Soil Venting Stack" stack. This card lists several phenomena that can cause one to achieve less than ideal removal rates. Take the time to explore each of these options, then return to card 19 of the "Soil Venting Stack" stack.

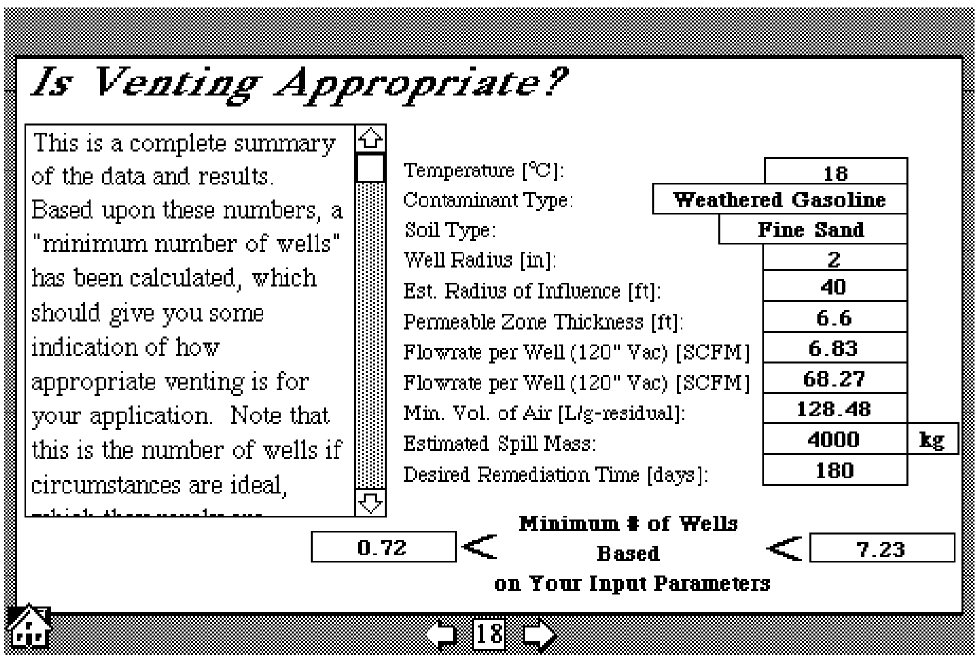


Figure 19. Card 18 of the "Soil Venting Stack" stack.

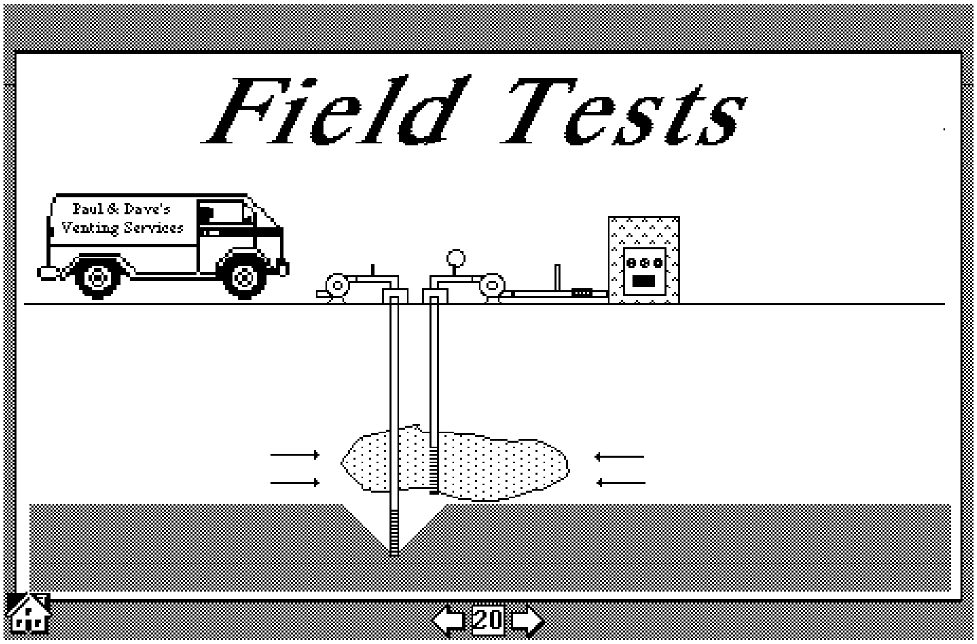


Figure 20. Card 20 of the "Soil Venting Stack" stack.

V.3.3 Sample Problem Exercise - Field Permeability Test.

Note: *It is recommended that you always plot and visually inspect your data prior to attempting to fit it to any theory.*

In this example, we use **HyperVentilate** to analyze air permeability test data from the site pictured in Figure 10. We will focus on results from the lower fine to medium sand zone (45 - 50 ft below ground surface). Advance to card 20 (Figure 20) of the "Soil Venting Stack" stack to begin.

Step 1:
Location: Card 20 of the "Soil Venting Stack" stack.
Action: Using the right-pointing arrow, advance to card 21 of the "Soil Venting Stack" stack. Read the text, then click on the "Air Permeability Test" button.
Result: You are at card AP1 of the "Air Permeability Test" stack.

Step 2:
Location: Card AP1 of the "Air Permeability Test" stack
Action: Read the instructions, then click on the "Show Me Set-up" button. Take a look at the figure, then click the "Return" button to return to card AP1 of the "Air Permeability Test" stack. Now click on the "Test Instructions" button.
Result: You are at card AP3 of the "Air Permeability Test" stack.

Step 3:
Location: Card AP3 of the "Air Permeability Test" stack.

∇

Action: Read the text, look at the sample data (click on the "show me sample data" button) then enter the following values for this example:

soil layer thickness	= 6.6 ft
estimated radius of influence	= 50 ft
air permeability test flowrate	= 15 CFM

Click on the "-->Calculate<--" button to estimate how long the air permeability test should be conducted.

Result: Your results should match those displayed below in Figure 21.

Step 4: Location: Card AP3 of the "Air Permeability Test" stack.

Action: Click on the "Return" button to return to card AP1 of the "Air Permeability Test" stack. Then click on the "Data Analysis" button.

Result: You are now at card AP5 of the "Air Permeability Test" stack.

Step 5: Location: Card AP5 of the "Air Permeability Test" stack.

Action: Read the text, then step through cards AP6 and AP7, until you reach card AP8 of the "Air Permeability Test" stack.

Result: You are now at card AP8 of the "Air Permeability Test" stack.

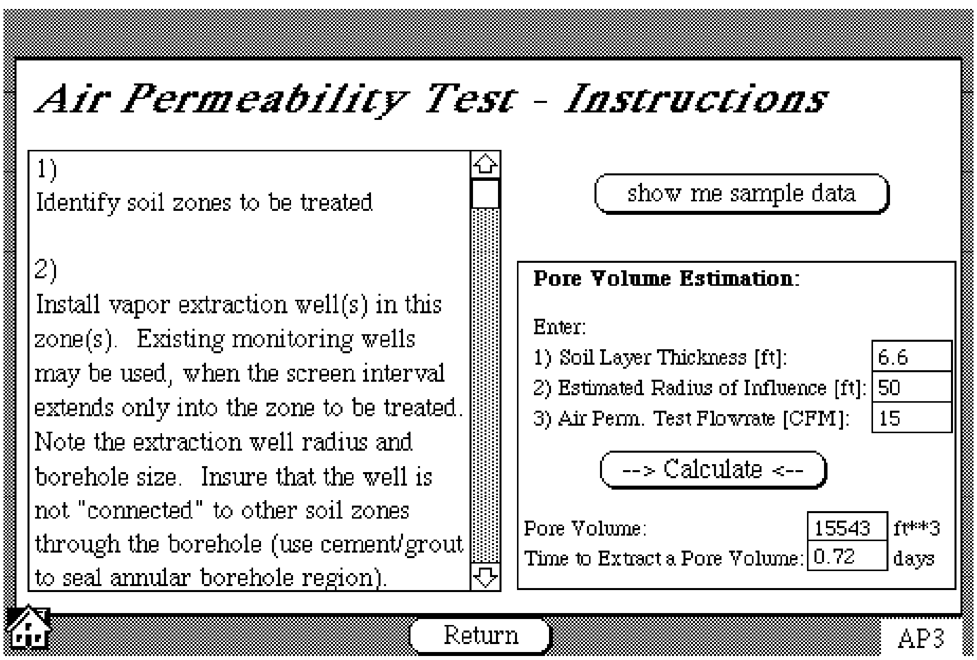


Figure 21. Card AP3 of the "Air Permeability Test" stack.

Step 6: Location: Card AP8 of the "Air Permeability Test" stack.

Action: Read the text, click the "clear" buttons to clear any entries from columns, then enter the following data:

r = 53 ft		r = 32.4 ft	
Time [min]	Gauge Vacuum [in H_2O]	Time [min]	Gauge Vacuum [in H_2O]
9	0.1	4	1.2
11	0.2	7	3.0
15	0.2	9	4.3
23	0.4	12	5.5
30	0.7	16	6.9
40	1.3	24	9.9
100	2.8	30	11
		39	13
		52	16
		77	20
		99	21
		110	23
		121	24.5
		141	25.5

flowrate = 15 SCFM
screened interval thickness = 6.6 ft

While entering the data it is convenient to place the curser in the time column, type in the time value, then use the "tab" key to advance to the vacuum reading column. Enter the corresponding vacuum value, then hit the "tab key again. As you see, this advances the curser to the time column again. Now click the "-->Calculate<--" button.

Result: Your results should match those displayed in Figure 22. Soil permeability values have been calculated by fitting the field data to the theoretical model described in cards AP5 - AP7 of the "Air Permeability Test" stack.

Step 7: Location: Card AP8 of the "Air Permeability Test" stack.

Action: Review the results, then click on the "Explanation & Statistics" button. This advances you to card AP9 of the "Air Permeability Test" stack, which lists correlation coefficients for the data fitting process. These values give an indication of how well the model describes the behavior observed in the field. Values approaching unity indicate a good fit. Your results should match those given in Figure 23.

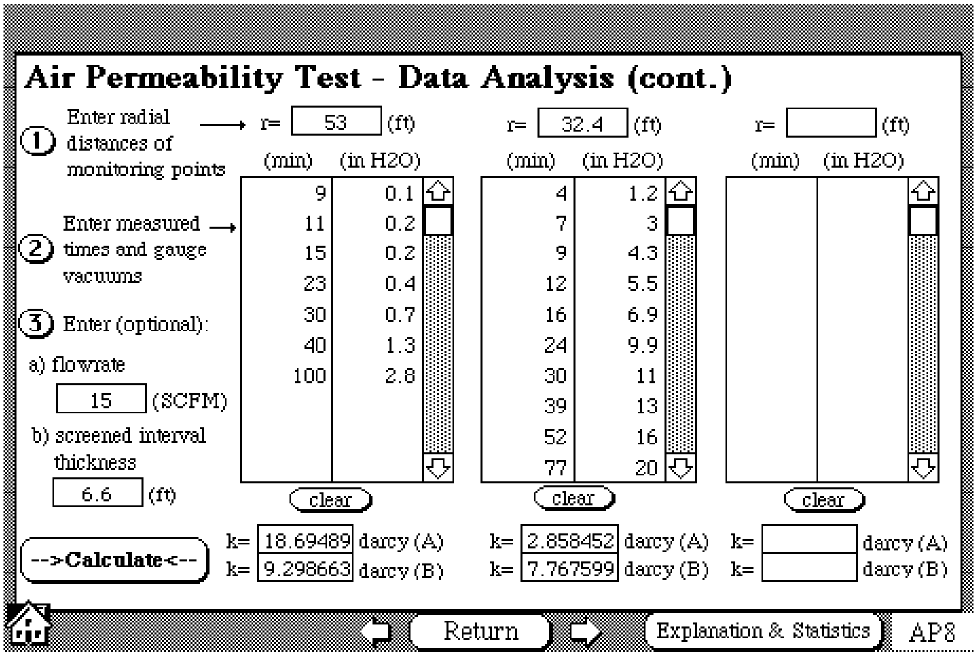


Figure 22. Card AP8 of the "Air Permeability Test" stack.

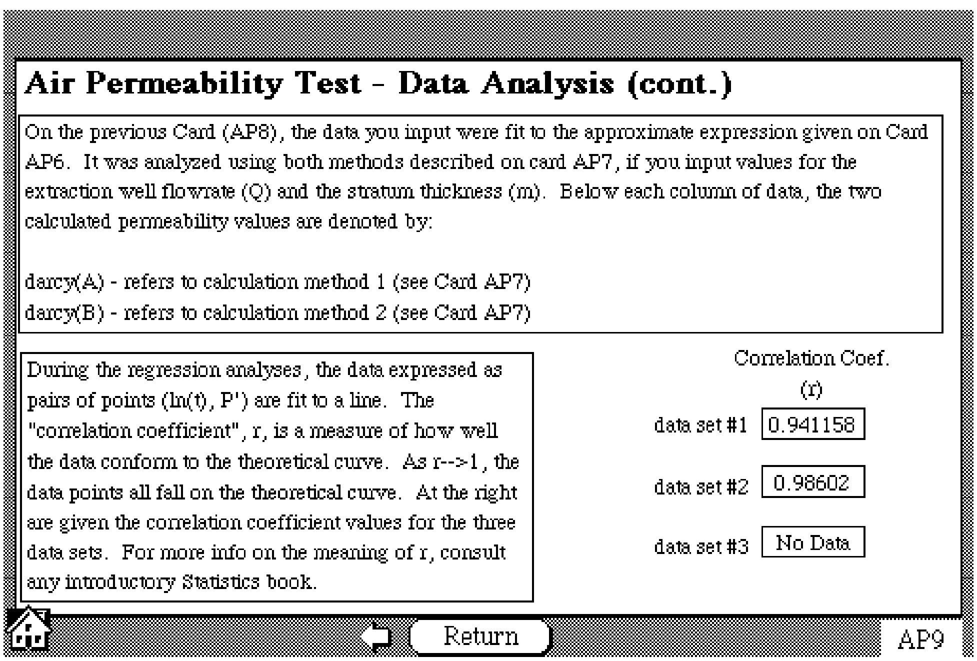


Figure 23. Card AP9 of the "Air Permeability Test" stack.

∇

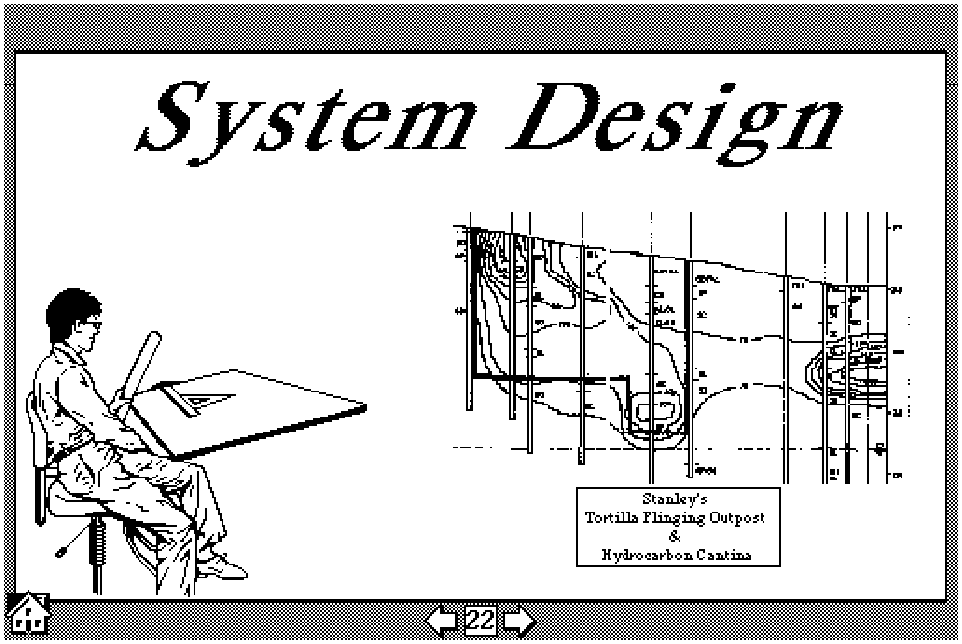


Figure 24. Card 22 of the "Soil Venting Stack" stack.

V.3.4 Sample Problem Exercise - System Design

In this example we illustrate the use of HyperVentilate for system design guidance. As in §V.3.2 and §V.3.3, we use the sample site presented in Figure 10. At this site gasoline was detected in three distinct soil strata: a fine to coarse zone located 10 - 30 ft below ground surface (BGS), a silty clay/clayey silt zone located 30 to 42 ft BGS, and a fine to medium sand zone that extends from 42 ft BGS to the deepest soil boring (60 ft BGS). Groundwater is detected in monitoring wells at about 50 ft BGS.

Advance to card 22 of the "Soil Venting Stack" stack to begin (Figure 24).

Step 1:
- Location: Card 22 of the "Soil Venting Stack" stack.
- Action: Use the right-pointing arrow to advance to card 23 of the "Soil Venting Stack" stack. Read the text, then advance to card 24 of the "Soil Venting Stack" stack.
- Result: Card 24 of the "Soil Venting Stack" stack, which appears in Figure 25, should be displayed.

Step 2:
- Location: Card 24 of the "Soil Venting Stack" stack.
- Action: Read the text, explore using some of the options. You will find that the options: "Well Location", "Well Construction", "Surface Seals", "Groundwater Pumping System", and "Vapor Treatment" provide some useful guidance information on aspects and components of a soil venting system. Return to card 24.
- Result: Card 24 of the "Soil Venting Stack" stack should be displayed.

∇

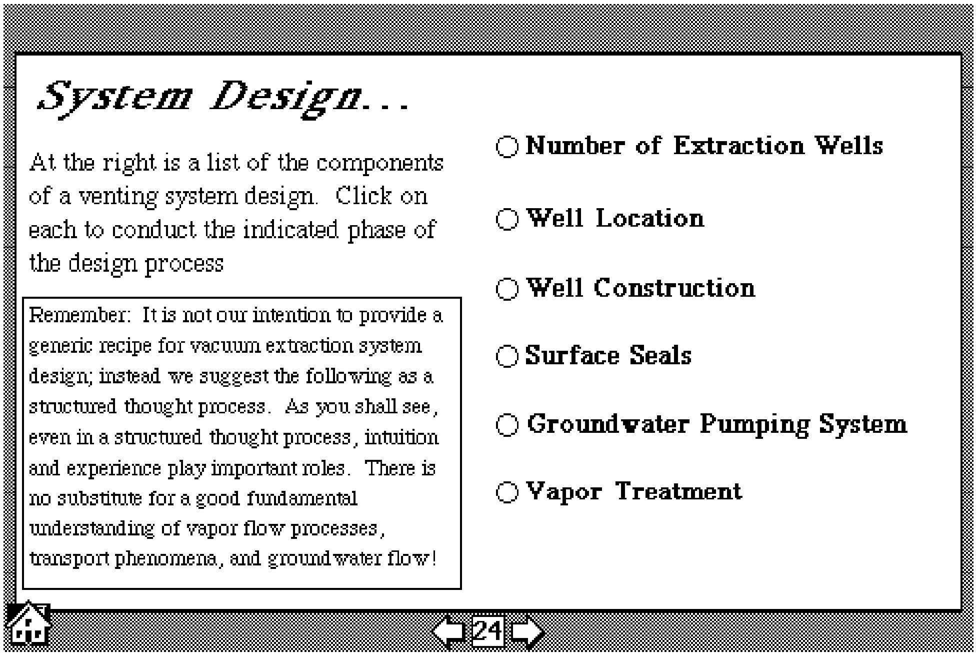


Figure 25. Card 24 of the "Soil Venting Stack" stack.

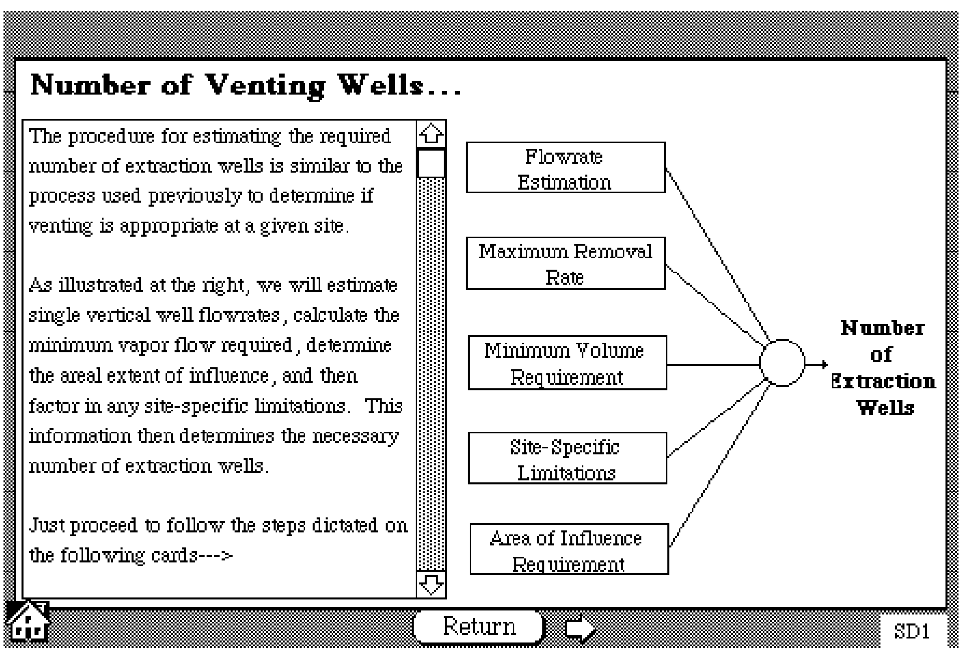


Figure 26. Card SD1 of the "System Design" stack.

∇

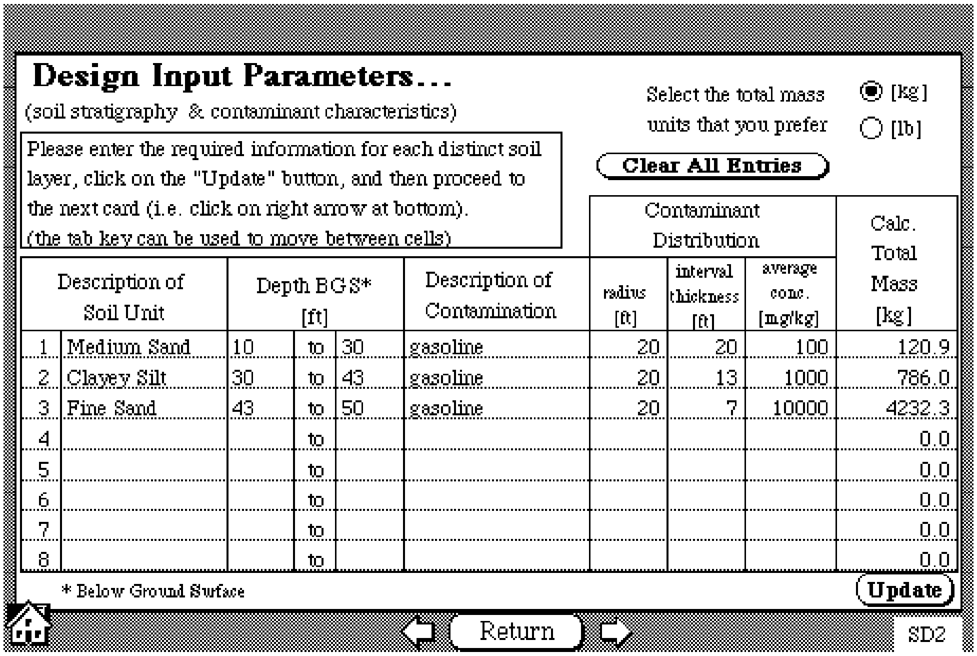
Step 3:	Location:	Card 24 of the "Soil Venting Stack" stack.
	Action:	Select "Number of Extraction Wells" from the list of options.
	Result:	Card SD1 of the "System Design" stack should be displayed, as pictured in Figure 26.
Step 4:	Location:	Card SD1 of the "System Design" stack.
	Action:	Read the text, then use the right-pointing arrow to advance to card SD2.
	Result:	Card SD2 of the "System Design" stack should be displayed.
Step 5:	Location:	Card SD2 of the "System Design" stack.
	Action:	Read the instructions on the card, enter the following values into the table, then click on the "Update" button:

		Soil Zone	
Parameter	**Medium Sand**	**Clayey Silt**	**Fine Sand**
subsurface interval (ft BGS)	10 -30	30 - 43	43 - 50
description of contaminant	gasoline	gasoline	gasoline
radial extent of contamination (ft)	20	20	20
interval thickness (ft)	20	13	7
average contaminant concentration	100	1000	10000

	Result:	Card SD2 should now resemble Figure 27.
Step 6:	Location:	Card SD2 of the "System Design" stack.
	Action:	Use the right-pointing arrow to advance to card SD3 of the "System Design" stack.
	Result:	Card SD3 of the "System Design" stack should be displayed.
Step 7:	Location:	Card SD3 of the "System Design" stack.
	Action:	Read the text. Note that "clicking" on many of the table headings will take you to "help" cards. Take a few minutes to explore the use of these, then enter the following information:

		Soil Zone	
Parameter	**Medium Sand**	**Clayey Silt**	**Fine Sand**
permeability (darcy)	10 - 100	0.01 - 0.1	1 - 10
design vacuum (in H_2O)	40	40	40
Well Construction:			
Radius of Influence (ft)	40	40	40
Extraction Well Radius (in)	2	2	2
Extraction Well Screen Thickness (ft)	10	5	5

∇



Design Input Parameters...
(soil stratigraphy & contaminant characteristics)

Please enter the required information for each distinct soil layer, click on the "Update" button, and then proceed to the next card (i.e. click on right arrow at bottom).
(the tab key can be used to move between cells)

Select the total mass units that you prefer ◉ [kg] ○ [lb]

Clear All Entries

	Description of Soil Unit	Depth BGS* [ft]			Description of Contamination	Contaminant Distribution radius [ft]	interval thickness [ft]	average conc. [mg/kg]	Calc. Total Mass [kg]
1	Medium Sand	10	to	30	gasoline	20	20	100	120.9
2	Clayey Silt	30	to	43	gasoline	20	13	1000	786.0
3	Fine Sand	43	to	50	gasoline	20	7	10000	4232.3
4			to						0.0
5			to						0.0
6			to						0.0
7			to						0.0
8			to						0.0

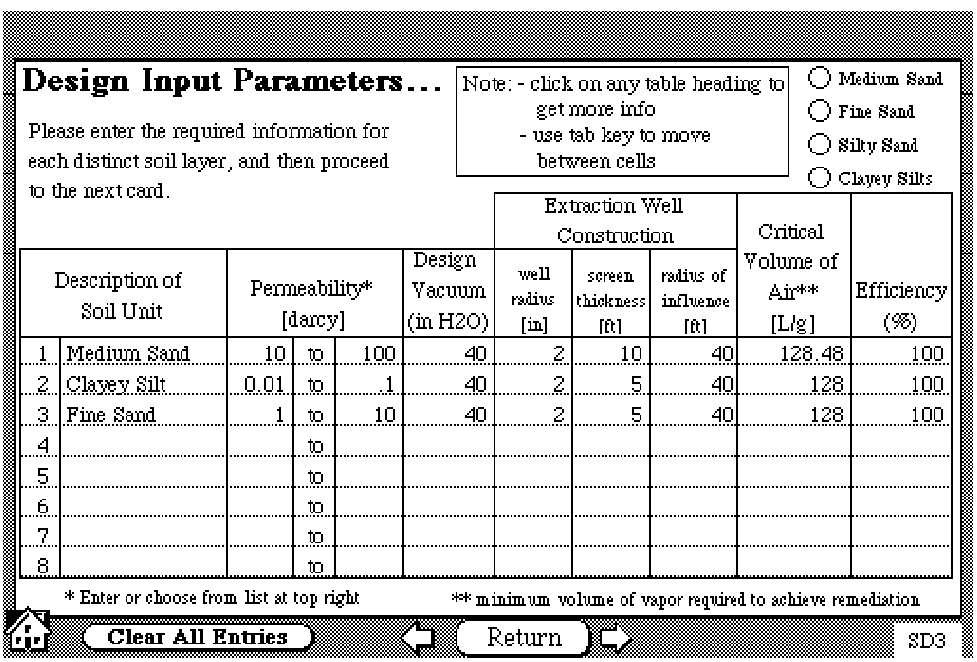
* Below Ground Surface

Update

Return

SD2

Figure 27. Card SD2 of the "System Design" stack.



Design Input Parameters...

Please enter the required information for each distinct soil layer, and then proceed to the next card.

Note: - click on any table heading to get more info
- use tab key to move between cells

○ Medium Sand
○ Fine Sand
○ Silty Sand
○ Clayey Silts

	Description of Soil Unit	Permeability* [darcy]			Design Vacuum (in H2O)	Extraction Well Construction: well radius [in]	screen thickness [ft]	radius of influence [ft]	Critical Volume of Air** [L/g]	Efficiency (%)
1	Medium Sand	10	to	100	40	2	10	40	128.48	100
2	Clayey Silt	0.01	to	.1	40	2	5	40	128	100
3	Fine Sand	1	to	10	40	2	5	40	128	100
4			to							
5			to							
6			to							
7			to							
8			to							

* Enter or choose from list at top right

** minimum volume of vapor required to achieve remediation

Clear All Entries

Return

SD3

Figure 28. Card SD3 of the "System Design" stack.

∇

The "Critical Volume of Air" is calculated by the same procedure used previously in §V.3.2 (steps 10 -13). To initiate this calculation, "click" on the "Critical Volume of Air**" heading.

Result: Card SD5 of the "System Design" stack appears on your screen (Figure 29).

Step 8: Location: Card SD5 of the "System Design" stack.

Action: Read the text carefully. The focus of this card is the prediction of vapor concentrations and removal rates as they change with time due to composition changes. It is important to try to understand the concepts introduced in this card. For more information, read the reference article contained in the appendix. Click on the "Do a Calculation" button to advance to card SD6 of the "System Design" stack (Figure 30).

Result: Card SD6 of the "System Design" stack appears on your screen.

Step 9: Location: Card SD6 of the "System Design" stack.

Action: This card is used to finalize your input data prior to calculating vapor concentration and residual soil contamination composition changes with time. Read the instructions in the order that they are numbered, then enter "18" for the temperature and select "weathered gasoline" from the three composition options. Because it is difficult to present the behavior of each compound in a mixture composed of an arbitrary number of compounds, the output is simplified by reporting the behavior in terms of "boiling point" ranges. This simply represents a summation of all compounds whose boiling points fall between pre-specified values. Presented in this fashion, the model results can be interpreted much more quickly. Click on the "tell me more about BP ranges..." button, read the help card, then return to card SD6 of the "System Design" stack. Click on the "-->Set Default BP Ranges<--" button. Your screen should now look like Figure 30. Click on the "Generate Predictions" button

Result: The message "Sit Back and Relax..." will appear on your screen, followed by a screen on which the following appears:

"Copyright © Absoft Corp 1988
Copyright © Shell Oil Co 1990
HANG ON ----- YOU WILL BE RETURNED TO HYPERCARD...
OF COMPOUNDS IN LIBRARY = 62"

Then card SD7 of the "System Design" stack will appear as shown in Figure 31.

∇

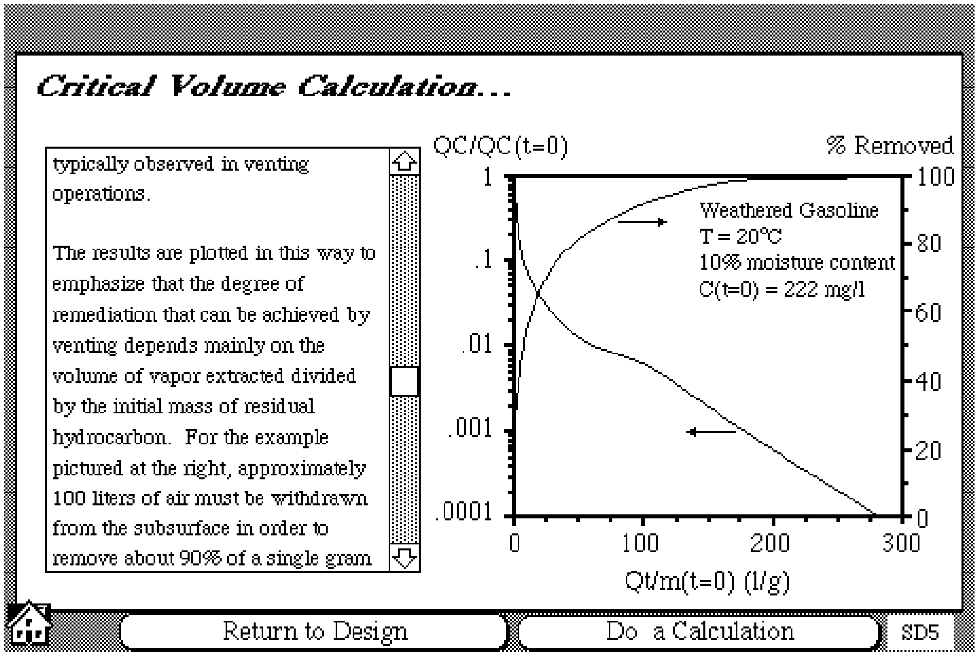


Figure 29. Card SD5 of the "System Design" stack.

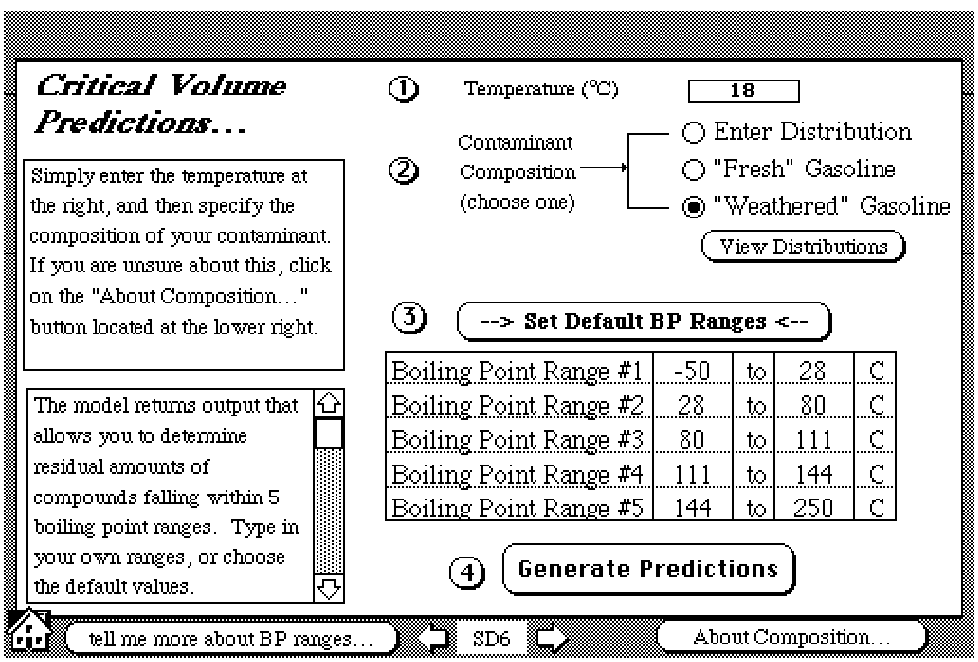


Figure 30. Card SD6 of the "System Design" stack.

∇

Step 10: Location: Card SD7 of the "System Design" stack.
Action: Read the instructions, then click on the "-->Import Data<--" button.
Result: Your screen should look like Figure 31. The table in the lower part of the card lists model predictions: vapor concentration and residual soil concentration (expressed as a percentage of their initial values), as well as the composition of the residual (expressed as a percentage of the total for each boiling point range) as a function of the amount of air drawn through the contaminated soil. Note that as the volume of air drawn through the soil increases, the vapor concentration and residual soil levels decrease, and the composition of the residual becomes richer in the less volatile compounds (BP Range #5). In the upper right corner of the card are displayed the saturated, or initial, vapor concentration and the minimum amount of air that must be drawn through the soil per gram of initial contaminant to achieve at least a 90% reduction in the initial residual level. This value is used in future calculations as a design parameter.

Step 11: Location: Card SD7 of the "System Design" stack.
Action: Click on the "Return to System Design" button
Result: A dialog box will appear asking: "Transfer Critical Volume Value?". Click on the "Yes" button. You will now be prompted by another dialog box asking: "What soil unit # is this value for?". Enter "1" into the appropriate place then click on the "OK" button. You will now be transferred back to card SD3 of the "System Design" stack. Note that the value "128.48" has been entered into the "Critical Volume of Air**" column for the medium sand soil unit.

Step 12: Location: Card SD3 of the "System Design" stack.
Action: Enter "128" into the "Critical Volume of Air**" column for the clayey silt and fine sand soil units. For this example problem enter "100" for the efficiency in all three soil units
Result: Card SD3 should now resemble Figure 28.

Step 13: Location: Card SD3 of the "System Design" stack.
Action: Click on the right-pointing arrow at the bottom of the page to advance to Card SD4 of the "System Design" stack.
Result: Card SD4 of the "System Design" stack should appear on your screen.

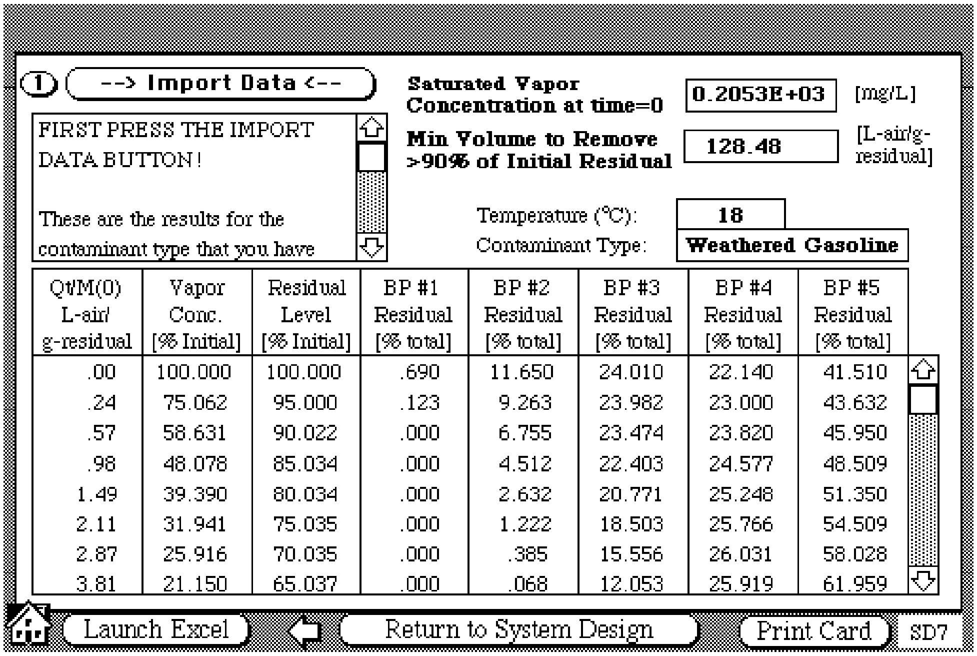
Step 14: Location: Card SD4 of the "System Design" stack.
Action: Assume that you wish to remediate this site in 180 days. Enter "180" in the "Time for Clean-up" column for each soil unit. Click on the "Update" button.
Result: **HyperVentilate** calculates a range of flowrates to a single vertical well, then uses this value and other input parameters to determine the minimum number of wells required based on two approaches.

∇

To read about these, click on the "Number of Wells" column heading. Your card SD4 should resemble Figure 32.

It is important to recognize that model predictions are intended to serve as guidelines, and are limited in their ability to describe behavior that might be observed at any given site. One should use all the information available, in addition to idealized model predictions to make rational decisions about the applicability of soil venting.

You can read about the effect of venting at this site in the article: "Soil Venting at a California Site: Field Data Reconciled with Theory", by P. C. Johnson, C. C. Stanley, D. L. Byers, D. A. Benson, and M. A. Acton, in *Hydrocarbon Contaminated Soils and Groundwater: Analysis, Fate, Environmental Health Effects, and Remediation Volume 1*, P. T. Kostecki and E. J. Calabrese, editors, Lewis Publishers, p.253 - 281, 1991.



① --> Import Data <--

FIRST PRESS THE IMPORT DATA BUTTON!

These are the results for the contaminant type that you have

Saturated Vapor Concentration at time=0 0.2053E+03 [mg/L]

Min Volume to Remove >90% of Initial Residual 128.48 [L-air/g-residual]

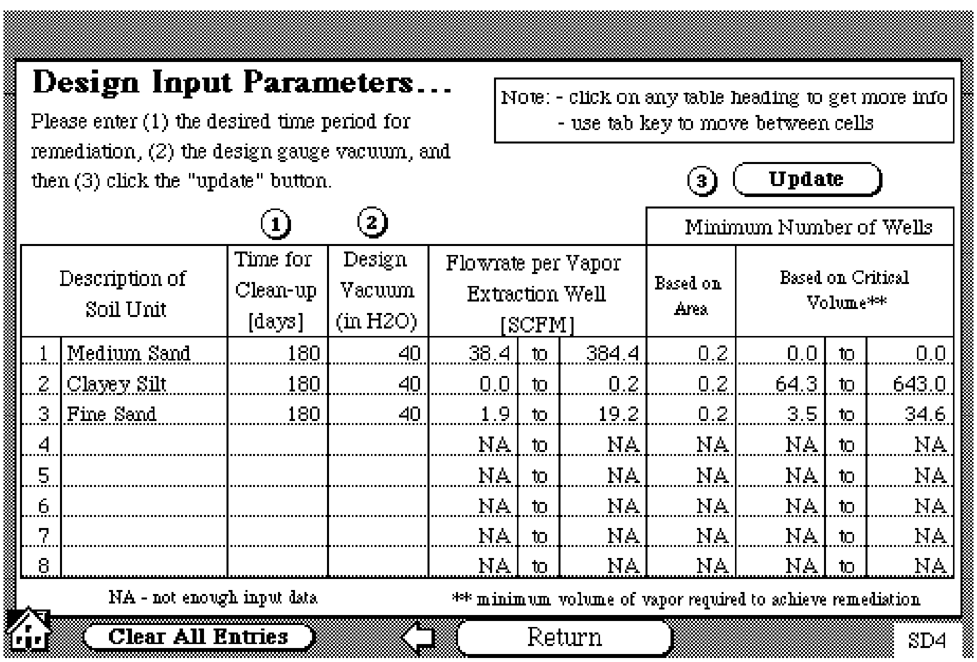
Temperature (°C): 18

Contaminant Type: **Weathered Gasoline**

Qt/M(0) L-air/ g-residual	Vapor Conc. [% Initial]	Residual Level [% Initial]	BP #1 Residual [% total]	BP #2 Residual [% total]	BP #3 Residual [% total]	BP #4 Residual [% total]	BP #5 Residual [% total]
.00	100.000	100.000	.690	11.650	24.010	22.140	41.510
.24	75.062	95.000	.123	9.263	23.982	23.000	43.632
.57	58.631	90.022	.000	6.755	23.474	23.820	45.950
.98	48.078	85.034	.000	4.512	22.403	24.577	48.509
1.49	39.390	80.034	.000	2.632	20.771	25.248	51.350
2.11	31.941	75.035	.000	1.222	18.503	25.766	54.509
2.87	25.916	70.035	.000	.385	15.556	26.031	58.028
3.81	21.150	65.037	.000	.068	12.053	25.919	61.959

Launch Excel | Return to System Design | Print Card | SD7

Figure 31. Card SD7 of the "System Design" stack.



Design Input Parameters...

Please enter (1) the desired time period for remediation, (2) the design gauge vacuum, and then (3) click the "update" button.

Note: - click on any table heading to get more info
- use tab key to move between cells

③ **Update**

	Description of Soil Unit	① Time for Clean-up [days]	② Design Vacuum (in H2O)	Flowrate per Vapor Extraction Well [SCFM]			Minimum Number of Wells: Based on Area	Minimum Number of Wells: Based on Critical Volume**		
1	Medium Sand	180	40	38.4	to	384.4	0.2	0.0	to	0.0
2	Clayey Silt	180	40	0.0	to	0.2	0.2	64.3	to	643.0
3	Fine Sand	180	40	1.9	to	19.2	0.2	3.5	to	34.6
4				NA	to	NA	NA	NA	to	NA
5				NA	to	NA	NA	NA	to	NA
6				NA	to	NA	NA	NA	to	NA
7				NA	to	NA	NA	NA	to	NA
8				NA	to	NA	NA	NA	to	NA

NA - not enough input data

** minimum volume of vapor required to achieve remediation

Clear All Entries | Return | SD4

Figure 32. Card SD4 of the "System Design" stack.

References

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Marley, M. C., and Hoag, G. E., Induced Soil Venting for the Recovery/Restoration of Gasoline Hydrocarbons in the Vadose Zone, NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater, Houston, TX, 1984.

Marley, M. C., Baehr, A. L., and Hult, M. F., Evaluation of Air-Permeability in the Unsaturated Zone using Pneumatic Pump Tests: 1. Theoretical Considerations, in review, 1990.

Thornton, J. S. and Wootan, W. L., Venting for the Removal of Hydrocarbon Vapors from Gasoline Contaminated Soil, J. Environ. Sci. Health, A17(1), 31-44, 1982.

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Appendix A: "Soil Venting Stack" stack cards.

Appendix B: "Soil Venting Help Stack" stack cards.

Appendix C: "Air Permeability Test" stack cards.

Appendix D: "Aquifer Characterization" stack cards.

Appendix E: "System Design" stack cards.

Appendix F: "Compound List Update" stack cards.

Appendix G: Reprint of:

"A Practical Approach to the Design, Operation, and Monitoring of In Situ Soil Venting Systems"